APRIL 1959

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ILLUMINATING ENGINEERING

Journal of the
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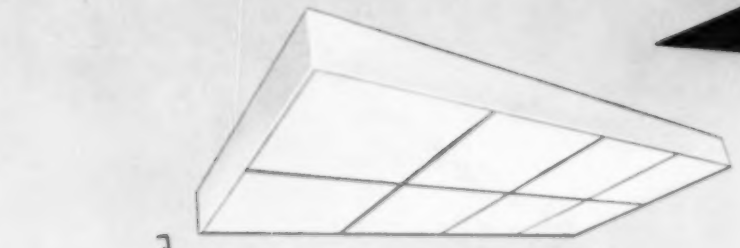
Information You Can Use

WAKEFIELD TWENTY

4 x 4 ft., 4 x 6 ft., 6 x 6 ft., 4 x 8 ft., 6 x 8 ft.



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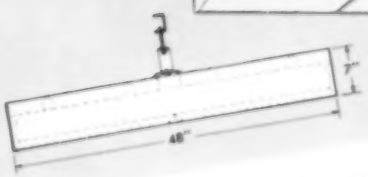


A quickly installed pre-assembled luminous ceiling unit, the Wakefield Twenty is mounted by two connections from the channel. The back channel is formed to take a "C" clamp. Thus in about twenty minutes an electrician can mount a complete luminous area. The units can be butted side by side and connected by bolts through knockouts in the steel sides. Cord and plug sets are provided so units can be connected without expensive electrical work. Main body is 20 gauge steel. Cross tees are .062" extruded aluminum and are removable. Top is open and is usually pulled up within inches of the ceiling. When units are placed side by side, the flange formed by the two sides is the same width as the cross tees, giving an appearance of one complete unit.

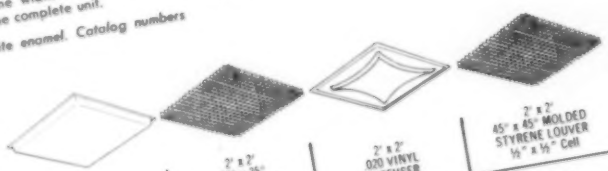
Finish—infra-red baked white enamel. Catalog numbers include body with mounting straps, 4" long threaded ⅜" solid steel suspension rods and assembled grid with indicated light control.

LIMITATIONS:

Although the unit is designed for suspension, it can be mounted directly on the ceiling. Provision must then be made for a light seal between top of unit and ceiling.

SPECIFYING POINTS FOR ARCHITECTS AND ENGINEERS:

Pre-assembled unit. 20 gauge steel and .062" extruded aluminum. Infra-red baked white enamel. Designed so it can be mounted in position in about 20 minutes.



	ALL UNITS ARE 7" DEEP	2' x 2' 060 STYRENE DIFFUSER	2' x 2' 35° x 35° STEEL LOUVER ⅜" x ⅞" Cell	2' x 2' 020 VINYL DIFFUSER	2' x 2' 45° x 45° MOLDED STYRENE LOUVER ½" x ½" Cell
4' x 4'	4-F48T12 SLIMLINE	TWS-444	TWS-444-L	TWS-444-VV	TWS-444-LL
4' x 6'	4-F72T12 SLIMLINE	TWS-446	TWS-446-L	TWS-446-VV	TWS-446-LL
6' x 6'	6-F72T12 SLIMLINE	TWS-666	TWS-666-L	TWS-666-VV	TWS-666-LL
4' x 8'	4-F96T12 SLIMLINE	TWS-448	TWS-448-L	TWS-448-VV	TWS-448-LL
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CONNECTING DEVICES (Unattached). 36" long 3-wire outlet connector cord and male plug No. GE 4673-3, 20 amps.
3-wire twist lock bridge connector equipped with male and female plug for interconnection, 20 amps.
When interconnected, supply sketch with order for correct placement of cords and plugs.

This is one of several dozen "spec" sheets, printed on both sides, giving concise data on Wakefield's many commercial and industrial lighting units. We'll be glad to send them to you.

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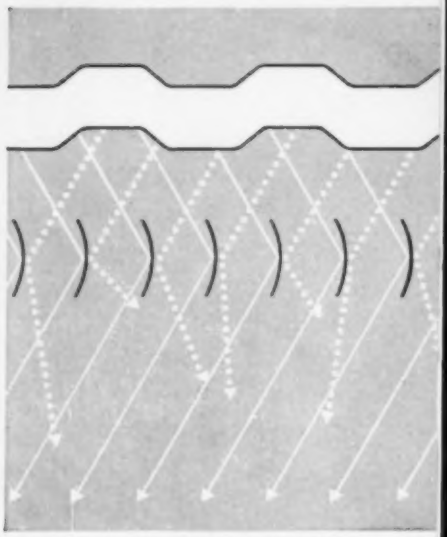
Large-area Power-Lux luminaire combines high photometric efficiency with attractive, modern appearance.



Parabolic louvres distribute 60,000-lumen output for high-intensity, low-brightness illumination.

Over 200 footcandles with Power Groove lamps

New LPI Power-Lux luminaire for stores has been engineered for comfortable brightness using Power Groove lamps

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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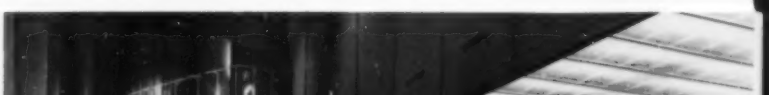

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Texas...

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Curtis Strato-Lux provides high levels of glare-free illumination to promote efficiency and serenity. Exceptionally low ceiling brightness is achieved through use of #6025 Holophane acrylic plastic Controlens.

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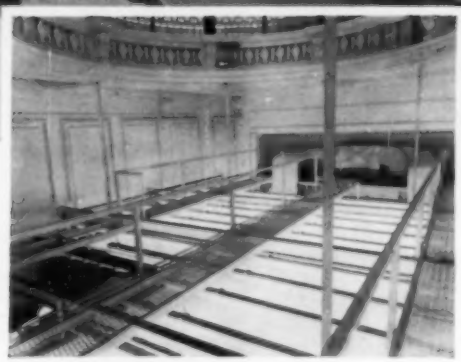
Visioneers in Planned Lighting



Remodelling? Give the Lighting a Fresh Look with a Luminous Ceiling by LITECONTROL!

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AREA SHOWN: Main Banking area
ARCHITECT: W. H. Jones & Son, Melrose, Mass.
ELECTRICAL ENGINEER: Martin E. Keane Associates, Boston, Mass.
ELECTRICAL CONTRACTOR: Walter Reddin, Portsmouth, N. H.
DISTRIBUTOR: Mass. Gas & Electric Supply Company, Portsmouth, N. H.
FIXTURE: Litecontrol Luminous Ceiling, using molded plastic grid louvers. Slimline single-lamp strip fixtures on 24" centers.
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Keys to More Beautiful Livable Home Grounds

By ASHLEY C. NORCROSS
M. VIOLA BRINER
MARY E. WEBBER

Contemporary House and Grounds Design

The design of today's house-and-grounds reflects a definite trend in contemporary living brought about by many changes and ideas introduced from other parts of the world during the past decade. The desire for simple, convenient out-of-doors living, now so popular, has also influenced this trend.

The indoor-outdoor relation of the house-and-grounds has been greatly facilitated by the use of expansive glass panels. The immediate out-of-doors areas are being interpreted with indigenous or synthetic materials skillfullly combined with the architecture to make the whole harmonize pleasingly with the setting or natural environment, and to serve their intended purposes efficiently.

Plants or living materials used outdoors should be carefully selected for the particular part which they are to play: enclosure (in three dimensions), delineation of pattern (both horizontally and vertically), scale relation, form, color and seasonal interest. Trees, because of their size, are the dominant plant in the landscape, and are often featured as specimens. They are also used to give scale, to produce a change in direction from the horizontal to the vertical, to produce a "ceiling" and a skyline, and to provide shade. Among the characteristics of a tree which the landscape architect uses in his design, each to be considered in the lighting, are form or branching habit, texture, color, seasonal changes in foliage and flowering and fruiting effects.

Shrubs represent varying degrees in scale and may serve some of the same functions as trees. They may be used as specimens, grouped in combinations or in masses, clipped to form hedges, or trained as espaliers or wall shrubs. Vines, occupying very little ground space, provide vertical accent in relation to structures and add interesting details of form, texture and color to the whole.

Grasses, used traditionally for covering ground area and for expressing horizontal expanses in the garden design, form the setting for various out-of-door games, recreations and other activities. Ground covers are used for producing pattern on the ground, and in combination with trees and shrubs. Sometimes they are used instead of grass to control soil on steep slopes or banks, or in areas where grasses cannot be established because of shade or other factors.

Flowers, in the contemporary garden, provide areas of color in the desired height and form and add fragrance and seasonal variation to the landscape. Often, the flowers trace the basic design of a garden or garden area, and modular units offer varying and unlimited relationship to architecture, interior and grounds, thus inspiring frequent changes in color and light.

Well-chosen ornaments, decorative accessories and other features or areas of special interest may be used for accent. Sundials, birdbaths, fountains, pools or water basins, plaques and pieces of sculpture are familiar examples. The accessories chosen may be either man-made *objets d'art* or interesting trophies collected from nature, but they should always be in good scale relation to the whole, and suitable in material, color and purpose.

Fundamentals of Night Lighting for Small Gardens

In spite of all that has been written, talked about and accomplished in the field of outdoor home lighting, the relatively modest home garden has suffered monumental neglect. Literally millions of small garden owners have, in general, seen nighttime lighting effects only at home and garden shows, fairs, in magazines or in the more pretentious gardens of estates. All of these spell high cost and luxury.

How then are we to reach and serve these

AUTHORS: Mr. Norcross and Miss Briner, Landscape Architects, Garden Center of Greater Cleveland, Cleveland, Ohio; Miss Webber, Residence Lighting Specialist, Large Lamp Department, General Electric Co., Cleveland, Ohio. This article is based on a paper presented by Mr. Norcross and Miss Webber at the Residence Lighting Forum of the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.

owners and lovers of small gardens, to assure them that delightful and livable nighttime lighting is available at moderate costs? How can we guide them in planning, one step at a time if necessary, for appropriate and harmonious composition?

In studying the problem, it is imperative to understand the goals of the landscape architect, both to broaden the landscape lighting goals and to resolve the lighting design with the house plot design. Although the landscape architect necessarily does most of his work on the grounds of relatively high income families, he is, through books, magazines, lectures and garden clubs, the recognized authority, who supplies the guiding principles for most home gardeners.

The most important single consideration in creating an outdoor lighting plan is no different, basically, from that of an indoor lighting job. The progressive residence lighting specialist or lighting sales person must understand the family's "living pattern" before he can produce a practical and appropriate plan. Only this approach can bring one to the necessary subjective viewpoint: that of the family and its requirements.

The development of the "living pattern" for outdoor lighting falls into the following considerations or "keys."

Space Relation and Use — In the house-and-grounds development, good scale relationship is sought. It is essential that the gardens compliment and be an extension of the interior areas to which they are adjacent and from which they are viewed. Also, they should be screened from the street. Note how these relationships are handled in the house-and-grounds plan in Fig. 1. Although there may be more than one garden "spot," as in this case, the areas are small to be in scale with the modest homes and lot sizes considered here. For this reason, and for cost reasons, the number of equipment items and the desirable light levels are modest. (Note brightness ranges in Table I.)

Light level is, of course, affected by the family's use of the grounds. These include, in this discussion, the casual visually functional areas — those for eating, circulating and non-active games, and the purely esthetic areas which offer appealing views.

A garden or home ground differs from the indoors in that although the boundaries are *defined*, the area is not *confined*. Spatially, the outdoors stands with reference to infinity, and the sky is literally the limit. One or more sides of the home grounds or out-of-doors living area may be enclosed by a wall, hedge, fence or building facade. Treetops and sheltering devices may form a partial ceiling. Large areas may be floodlighted for recreational use, but merely flooding a garden with light in an attempt to disperse the darkness defeats the artistic purposes of light and its applications in creating glamor, enchantment and pictorial associations in the garden.

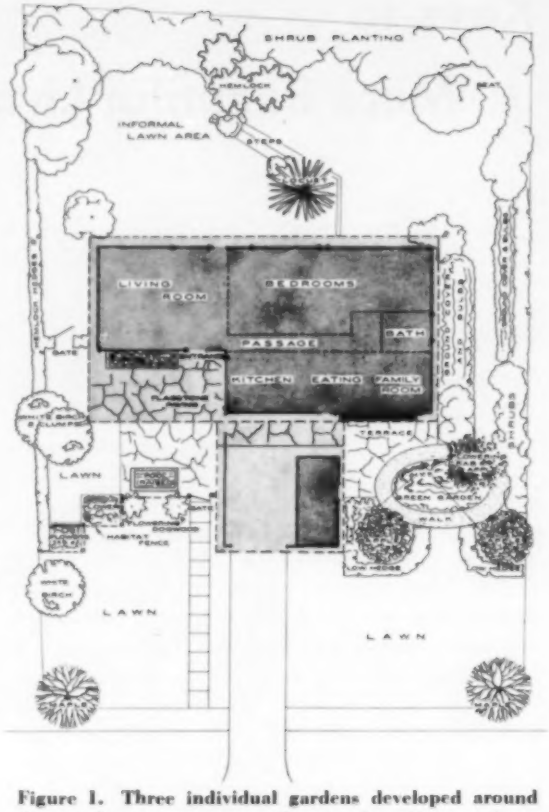


Figure 1. Three individual gardens developed around this modest contemporary house give pleasure from within and without the house and provide privacy from street and neighbors. The gardens are planned so that there is easy circulation between gardens and interior and variation in horizontal and vertical design and in materials used.

Perspective is a vital quality to be maintained at night. It may be emphasized or expressed by light treatment, with attention given to these suggestions:

(1) Foreground, when it is a terrace or inside room used functionally and/or as a viewing position, should have the highest lighting level in the entire area. This level, however, must be relatively low (averaging three to eight footcandles) to allow enjoyment of the garden vista. Terrace lighting should be planned so that it can be switched easily to a lower level, to strengthen the visual impression of the garden scene.

(2) Middle Area between the foreground and background, lighted in a considerably lower key,

gives a sense of increased distance. If shadow patterns are developed here, interest is added. Further advantage may be taken of shadows by using them to produce broken as well as solid patterns, and to introduce the excitement of movement from branches or foliage. The object from which the shadow is cast, building, plant, ornament or tool, does not necessarily need to be visible.

(3) Background should not be strongly floodlighted, although defining boundaries should be made clear with specific light emphasis on the vertical elements that aid the eye's movement toward infinity or the "ceiling" of the garden design. Here it is desirable to screen out, in darkness if possible, unsightly or undesirable elements such as poles and garages. Low flooding from house or trees (.1 to 1 footcandle) is most desirable for integrating the scene. When a house is within about 50 feet of the defined background, the 75-watt PAR lamp is desirable, although more than one may be needed for coverage. Some families, especially those who have recently acquired a "light-conditioned" home, may start their backyard lighting by floodlighting from the two rear corners. If there are trees or shrubs at the back of the lot, this crosslighted effect may seem enchanting. However, with time, the family is quite apt to want the greater interest of interplay of highlight and shadow. Bluish-white light on background shrubs and trees often gives a sensation of greater depth. Continuous even light should be avoided because it defeats depth effects.

Contour is a most important factor in good house-and-grounds design. Interesting form developed by flower borders or beds and changes in ground elevation effected by shrubs, walls, fences and trees should be studied by the lighting designer so that he may define and make clear with his lighting pattern, their fundamental contributions to the landscape composition. This nighttime lighting may either emphasize or imply the contour pattern, but it should lead the eye over the scene in the same way as the contours and defining patterns do during the day. When there is a planned relation between the house and the landscape contour, the lighting should "hold" this relationship.

Special details of intrinsic beauty in the garden scene, such as water features, garden ornaments or choice blooms, usually call for the highest lighting levels. These high levels create points of special interest and attraction, but they should not be excessively bright. One element should usually take precedence over all others in any "picture."

Imaginative and subtle qualities add to the mystery and delight of nighttime lighting effects. Such qualities are utterly defeated by visible light sources or even by luminous parts of equipments other than those located on the terrace or within eating areas. Even in the latter areas very low wattage lamps are required if the results are to be enjoyed, unless the luminous areas of the fixtures are very low in light transmission. When equipment cannot be concealed, it should be selected and placed so as to be as inconspicuous as possible and to harmonize with the surroundings in color, form and concept. These latter types of equipments are considerably more expensive than equipments which can be completely hidden (those used primarily in the application examples in this article). Average budgets allow very few of the visible types of equipment.

Some people seem to prefer "bulb-showing" fixtures and more obvious lighting treatments than those shown here. These, however, cannot generally play much part in an enchanting garden scene.

Wiring

Before the guiding principles of garden lighting can be discussed, just as before any equipment can be installed, the wiring must be planned with safety and electrical supply in mind. In the planning stage of new homes it is short-sighted not to specify a complete and realistic wiring plan for extended outdoor living — permanent and serviceably controlled. Even when the grounds plan has

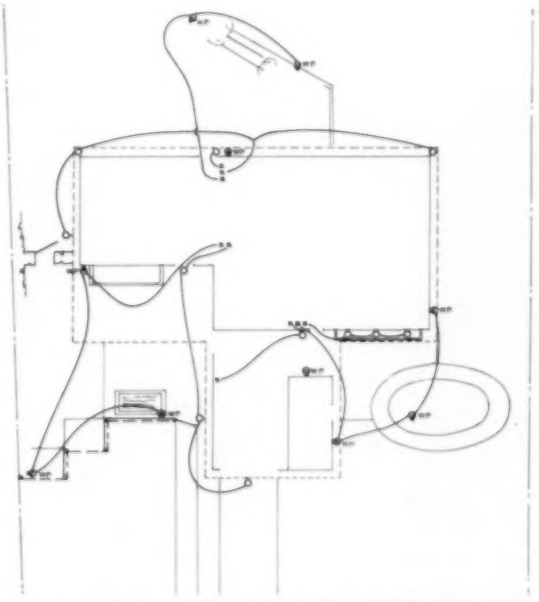


Figure 2. This outdoor wiring layout (three circuits for grounds shown in Fig. 1) represents realistic and long-range economy planning and affords convenient indoor control.

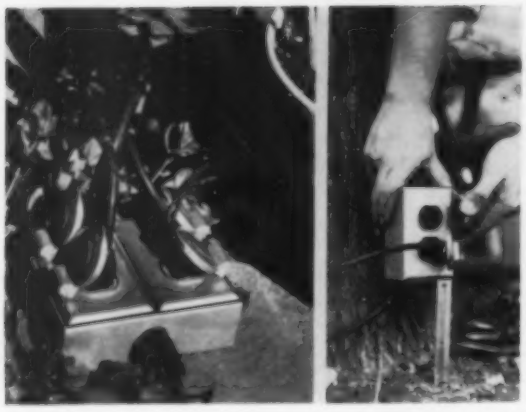


Figure 3. Weatherproof boxes such as these should be set up or spiked above ground and placed so that they are concealed from usual viewing angles. Shown here are, left, two-gang type and right, one-gang type, as described in the footnote to Table I.

not been decided upon, a study of the plot plan and a fair understanding of house-and-grounds design will enable the lighting specialist to make reasonable "guess-timates" on the location of outlets away from the house.

Fig. 2 shows the outdoor wiring plan for the house-and-grounds plan shown in Fig. 1. Each of the 11 lighting outlets on the house have specific protective, safety-in-circulation or decorative ground lighting purposes. Underground wiring to convenience outlets away from the house is necessary to avoid surface wiring across lawn, terrace or path areas. The two outlets without switch control are for cooking and garden power equipment. Each of the three garden areas is separately switch-controlled from its coordinated area.

In regard to safe, dependable wiring for *existing* yards of the type under discussion, there is evidently a need for a more specific suggestion than "weatherproof" equipment. Available surface extension sets of the type shown in Fig. 3 and described in the footnote to Table I, are preferred. The three-wire grounded type is recommended and is in keeping with the present trend.

When wire runs exceed 50 feet, some voltage drop may be expected, although this is not serious up to 100 feet. Molded weatherproof extension cords to jump from the receptacles to the equipments are difficult to purchase and consequently the user is forced to buy more receptacles and cord sets than would be necessary if manufacturers were to supply equipments in the added choice of 15- or 25-foot cords. Unfortunately, equipments are generally supplied only with 6- or 10-foot cords.

When three-way molded plugs are needed, they should be taped or wrapped tightly in waterproof, non-inflammable plastic to waterseal unused outlets. If the extension wire cannot be laid along from the power outlets near the house, fence, wall, lawn edge or between path stones so that it is not a hazard, an underground line, usually short in small plots, is essential.

In older homes and even in many of the newer small homes, there are no outside outlets, and one is forced to "pull" from the garage or from an entrance-way lighting unit. In such cases, circuits must be checked to avoid overloading. Seldom will a full circuit be required for small yards (see Table I).

Application Examples

Intimate Informal Terrace and Garden

Interestingly-designed terraces are the first areas to be considered in ground lighting. These are usually extensions of interior living spaces and are visible through windows (Figs. 4, 5 and 6). In the illustrations shown, gay, swinging bubbles, attached to a narrow roof overhang set the key for informal and casual living. The white plastic bubbles may be changed in color by a change of lamp. The use of strong 40-watt red and green

Figure 4. View through living room window shows how lighting extends the close relationship between indoor and outdoor living for after-dark enjoyment.

Figure 5. When owners have worked and planned for many years to attain this outdoor environment (seen here from second-floor bedroom) they find new pleasure in discovering its beauty after dark (Fig. 6).

Figure 6. Nighttime view of area shown in Fig. 5. The lighting "holds" the basic grounds design and features the interesting details and specimen trees.

lamps and 25-watt yellow sign lamps create a pleasing color mixture on the white and yellow furniture. On the teawagon often used for outdoor serving, there are five footcandles..

Definition of flagstone pattern at the far left of the terrace, as seen through a living room window in Fig. 4, is emphasized by a PAR lamp and baffle (75-watt) clamped to the eave at the left of the bubbles. The central beam of the lamp grazes the flower bed and the climbing roses covering the garage at the left, and establishes the starting point of the garden contour. An identical unit mounted at right angles to it is aimed so that the edge of the beam spread highlights and creates shadows of the potted plant on the lawn (Fig. 6). Since the terrace fixtures are connected to an existing outlet box on the terrace, any one of them may be disconnected when lower lighting levels are desired. Thus, the foreground lighting is readily adjustable from "living" levels to a much lower level, when interest is focused on the garden view.

Figure 7. Used in the silhouette outlining of the flower border (Figs. 4 and 6) are two 25-lamp outdoor Christmas strings equipped with 20 C9½ clear lamps. They are fastened above ground or in crevices on the low flagstone wall with heavy aluminum "hairpins" and are front-shielded by slightly curved aluminum sheets.

Figure 8. (left). Low-cost long-spike PAR lamp holder placed here to flood Scotch pine (Fig. 6) is shielded from view by a 12- by 12-inch aluminum sheet which also separates and protects ground ivy from lamps. In addition (inset), a 75-watt PAR38 floodlamp is attached with rubber-covered wire on tree trunk, 18 inches above ground on side toward terrace.

Figure 9. (below left). Short spike and plate PAR holder may be stabilized by brick hidden in ivy. Here it is shown with extra deep louver often required for shielding.

Figure 10. (right). Mottled black and green unit with deep ground spike uses R20 enclosed, 30-watt lamp. Inconspicuous, it is ideal for spotlighting small area garden features. It is used in areas shown in Figs. 4 and 6, respectively, to highlight a clump of white daisies (four feet away) and red-berried bush near bird feeder (20 inches away). Distance varies with reflectance of materials.

The middle area, between the terrace and the background, is kept in a low key. The enclosing hedge at the far end (Fig. 4) is purposely kept in near darkness to avoid the illusion of confinement. One knows the hedge is there, however, by the low lighting of the corner (at right) and by its cut-off of the poplar. An interesting and varied light pattern is created by the poplar's constantly-moving leaves, and the lighting of the tree itself gives the designer an opportunity to add depth to the scene.

The hedge, as it continues, encloses the back of the garden (Fig. 6) and is subtly visible, providing integration and background for the featured details of the setting. Most important is the clear definition of the curving low stone wall, its foreground flower border and the overhanging flowers above it. This definition is obtained through the use of outdoor Christmas strings (see Fig. 7). The lamps have purposely been spaced unevenly to avoid monotonous regularity, and the unused sockets in the strings have been Mylar-wrapped to keep them water-tight. These 4- by 6-inch homemade shields are cut from 25-gauge 9-square-foot aluminum sheets, available for about $3.00 in hardware stores. The side facing the viewer is spray-painted a grass green.

Placement of a 75-watt PAR lamp parallel to and at the base of the hedge emphasizes the textural quality of the hedge and accents the bird feeder in silhouette. The trees afford an opportunity for introducing more depth to the scene; the white pine to the right of the bird feeder (seen more clearly in the daylight view, Fig. 5) with its open branches and soft needles is faintly tinged with light directed straight up through the tree by a ground-placed handy flood unit. A low-output blue-tinted 100-watt lamp is used in the unit. Thus, the smaller pine tree does not vie with the featured grouping of Scotch pine and small crabapple tree.

This grouping is a "natural" for top lighting interest because of its mass and the interesting contrast in form, branch structure, texture, scale and color between the trees (Fig. 8). A 75-watt flood-

lamp is ground-spiked about 15 feet (approximate width of the branch spread) from the trunk of the Scotch pine, to the front left, and tilted to fill the tree height. In addition, to emphasize the open-branch structure and interesting bark texture of the Scotch pine, a second 75-watt floodlamp is installed. At the right of the Ely crabapple tree, a shielded PAR holder of the type shown in Fig. 9, equipped with a 100-watt pink projector lamp, is aimed from the ground to streak light diagonally through the tree. The pink lamp serves to enrich the color quality of the reddish leaves.

Shady Garden Retreats

These are delightful spots for daytime relaxation and dramatic places for late evening suppers. The picnic table (Fig. 12) cannot be placed under the apple tree, but it is shaded from the early evening lowering sun by the apple tree and the low spreading pin oak at left. For late evening use, the lighting is designed to highlight the table as the center of use and interest and to engulf the area with low but sufficiently suffuse light to allow safe circulation and provide esthetic interest.

The apple tree with its open spreading structure and wide spacing of nearly opaque leaves is the dramatic center of the garden. A properly shielded PAR lamp will *not* serve to light the tree because its beam is much too sharp and concentrated and results in a harsh streak of light confined to the central section of the low-branched tree. Instead, the wider diameter, more shallow

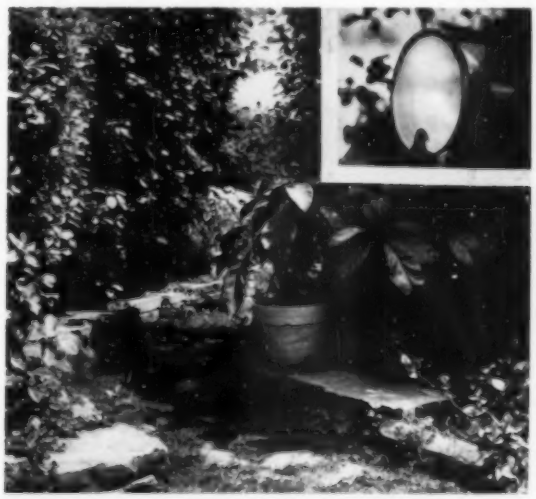


Figure 11. Inset shows "handy" floodlight, a most practical protector of non-waterproof lamps. Concealed behind potted plant and angled to reveal directly and by reflection, it is used with a 40-watt lamp for night lighting of this curving path and tall flanking hedge.

Figure 12. Delightful relaxing and eating area is glamorized at night by subtle light infiltration through beautifully formed apple tree. Tree is illuminated from reflector set into its crotch. When trees are set into lawn or terrace, underground wiring is needed to a receptacle at base of tree.

handy floodlight was fastened to the lower crotch of the tree. Slightly diffusing plastic was stretched over its clear cover glass to widen the light spread. Additional shielding, necessary because the unit was installed lower than is usual in the tree, was obtained from a surrounding strip of aluminum. Thus, the tree is infiltrated with light and the leaves act as tiny reflectors to create the low surround lighting. A 100-watt standard lamp was used in the installation shown, but an even more interesting effect (not easily photographed) is created by the use of a pale-tinted green lamp of the same wattage.

The hilltop area shown in Fig. 13 was selected for lighting because of its seclusion, its view and its esthetic possibilities. One important consideration in planning the lighting for this area was to assure safe passage to and from the house. A sloping path down from the house turns abruptly near the bubble, an 11-watt yellow sign lamp, and continues beside the back retaining wall. The path comes out through an opening in the low hedge behind the table.

The structural line and form of the trunks of the hawthorn trees suggested the use of oriental lanterns to focalize the limited seating area. The diffusing bottom plates supplied in the lanterns were replaced by clip-on louvers which provide better brightness control. To control the brightness of the lantern's grille openings and to highlight

Figure 13. This secluded garden area overlooks the city. Snug enclosure is attained by the tree "ceiling." Blue-white light and shadow are imaginatively combined on rear concrete retaining wall to create illusion of depth.

the table and surrounding grass through the nearly transparent glass table top, an R20 30-watt lamp was used. This lamp serves the afore-mentioned purposes far better than any standard line lamp. The cost of the two visible equipments comprise 65 per cent of the total cost of the equipments used here.

Three ground-spiked and baffled 75-watt PAR lamps were aimed to graze the tree trunks and cover the closely-spaced, highly-reflective leaves. A fourth identical unit, equipped with a 150-watt blue-white PAR lamp was angled at the retaining wall. This gives the illusion of depth and, to the imaginative eye, even of shimmering water.

Deep Narrow Back Yard

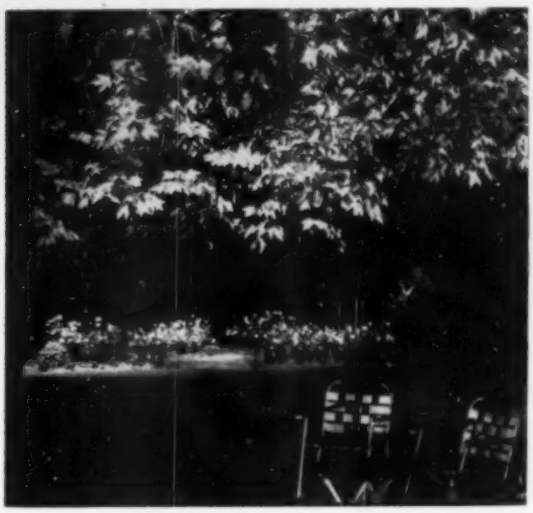
The 40-foot width of the area shown in Figs. 15 and 16 is filled by the house and a driveway to a rear garage. A back window in the kitchen-dining area and a screened-in porch look into the deep yard. Here, the owners have spent many hours developing a beautiful lawn and, at the rear, a specimen rose bed. Since the yard is not used after dark, the lighting here is intended solely to provide a satisfying view of the owners' handiwork and artistry.

This back yard was "light-treated" in a budget-minded three-step program. Actual costs of the equipments were less than are listed in Table I,

Figure 14. Practical garden living is provided by this screened-in garden house adjacent to a wooded ravine. Open-bottom yellow luminous units hang on vertical structural members for casual reading, and from ceiling to light the table. Deep-shielded bullet floods cooking center. Floodlighted flagstone in front and trees in back prevent closed-in feeling often experienced in a lighted area which is surrounded by darkness.

Figure 15. (left). Foreground of narrow deep yard receives first attention in three-step budget-minded lighting program, seen completed in Fig. 16 below. Translucent light green leaves of maple tree become luminous and reflective from floodlamps at tree base.

Figure 16. (below). In completed stage, light level is reduced in foreground, middle area is left in near darkness and the rose garden is the most strongly lighted area. Bluish-white tinted lamps are used throughout for their color enrichment of the greens, reds and pinks predominant in this area.



since the owner was employed where he could take advantage of a special promotion. The equipment used was a rubber-covered socket, adjustable vertically, complete with blue-white tinted PAR lamp and equipped with a 25-foot outdoor cord and a long spike. The spike has knock-outs so that it may be fastened to stakes or pieces of wood. The units may then be fastened to a house or tree. The wood can be cut at any angle for correct horizontal socket direction. Even though the socket is weatherproof, it is advisable to install a water-tight gasket on it.

Three of these units were spiked vertically, as shown in Fig. 15; two behind the two tree trunks (second tree to left, not visible in photograph) and one in front of the tree shown, to create a focal point of the geranium blossoms. Although the lamps are shielded from the house, they were concealed for better daytime appearance by home-devised cans, painted black on the inside and green on the outside.

In a second step, Fig. 16, the unit creating the near-focal point was removed, and with two additional ones, placed to floodlight the rose garden. Two units were mounted toward the front, high on the garage, and one, on a high stake, was placed at the right front side of the rose bed. Baffles were needed to conceal the light streak at the front edge of the PAR lamps, even though the units were aimed away from the house.

The cross-lighting resulting from this treatment, with more light coming from one side, gives a modelling rather than a flat effect. The background vine and rambler rose-covered wire fence "catch" sufficient light to clarify the garden's contour. The middle lawn area was left in near darkness. As a final step, a shallow green mushroom was added to give particular emphasis to a small circular rose bed in the center.

Pool and Garden

The eight- by eight-foot goldfish pool shown in Fig. 17 is just outside a family room window. It is extended on each side by low natural rocks and trailing ground cover. Three graduated shallow water bowls, identically placed on each side, project gentle waterfalls into the pool. They also stress the horizontal low elevation found in the composition.

The lighting, by William Eppard, interprets and accentuates perfectly, the individuality of the plan. Controlled horizontal cross-lighting from the beautifully scaled and formed low lighting equipment emphasizes the texture and form of the rocks and bowls. At the same time, the varied planting materials are highlighted to give strong shadow patterns.

A second identical lighting unit is centered in

Figure 17. This scene completes the wall-length picture window and becomes more exciting by night than by day. The small pool is flanked by rock gardens and shallow bowls that project miniature waterfalls into pool.

the flanking garden at left. An underwater unit, concealed by a metal replica of grouped lily pads creates bold silhouettes of the water hyacinths and lilies and the moving goldfish. The single little statue, purposely not highlighted, adds a sentimental note of special meaning to the owner.

Summary

Tables I and II give additional pertinent and, it is hoped, guiding data for all those concerned with the lighting of house-and-grounds. Table I, in particular, summarizes detailed information with respect to both the lighting and the dollars involved in the application examples.

The price ranges in the cases discussed are modest. This is particularly so in terms of the equipments needed for the effects illustrated and for the specified areas. It will be remembered that the great majority of equipments used were low-cost items, Fig. 7-11. These do not, of course, have the strong construction, built-in shielding and perma-

TABLE I — Summary Data on Experimental Gardens.

Figure No.	Area Square Feet	Lumens/ Square Foot	fL Range (Excluding highlights)	fL Range (Highlights only)	Approximate List Price Equipment and Lamps	Total Items Equipment and Lamps	Approximate Wiring*— List Price	Total Watts	Watts/ Square Foot
4, 5, 6 total garden including terrace	1750	5.6	.004 - 4	8 - 80**	$145.00	56	$48.00	1125	.65
4, 6 terrace only	130	13.5	2.5 - 8	Bubbles Green: 3 Red: 18 Yellow: 60	36.00	8	existing outlets	235	2.
12 shady hilltop	600	6.9	.003 - 4	10 - 80†	28.00	6	38.00 should be underground	325	.54
13 shady hilltop	525	7.1	.02 - 2.5	9 - 30‡	83.00	17	42.00	490	.9
14 garden, house and flagstone area	375	20.4	no data	no data	60.00	14	in house cost	615	1.6
15 foreground: outdoor seating area	450	3	.02 - 5	10 - 30	16.00	6	16.50	450	1
16 background: rose garden	400	4.5	.01 - 3	10 - 20	22.00	6	9.00	525	1.3

*Based on the use of weatherproof power outlet extensions, supplied with heavy duty 16 SJ wire with molded 3-wire plugs and with one or two gang boxes with duplex heavy duty, grounded 3-wire receptacles, 15 A-125V. Standard wire lengths, 10, 25 or 50 feet.
**Small leaves.
†Bark nearest reflector.
‡Openings in lantern grilles.

TABLE II — Suggested Watts per Linear Foot — Flower Borders or Narrow Beds.

Watts/Linear Foot	Lamp Type	Flower Height	Equipment and Location	Effect
3-5	C9½ clear	up to 30 inches against wall, fence or building	outdoor Christmas string hidden behind	low, subtle lighting by silhouette (Figs. 8, 9, 10)
5-10	C9½; S11 clear or white	12-30 inches (not viewed from rear)	front-staked shields, 6-15 inches high, 18- to 24-inch spacing	subdued but emphatic front lighting
13	C9½ clear or white	12-30 inches	trenched in front, 9-inch centers	subtle front and up lighting
3-5	25A or 40A IF or 75A bluetint	up to 20 inches	14-inch diameter shallow mushroom, 10-foot spacing	emphatic down lighting
10-15	75/R30 flood or spot	up to 36 inches, beneath house overhang	45-degree shielded reflectors on roof overhang, 7-12 feet above	strong down lighting

nency of available higher-priced equipments which produce the same effects. However, the types illustrated are practical "starters" for the greatest number of *modest garden owners*. These families, in most cases, must first learn the meaning and value to *them*, of extending their lighting out-of-doors.

Motivation to act and thereby to gain experience with this medium of expanding home living may gain faster momentum by:

(1) Increased industry effort to show more well-designed yet practical and dollar-wise examples of lighting in modest gardens to supplement the examples of lighting on more pretentious grounds. This will help overcome the false belief that these nighttime effects are only for a limited few.

(2) Special promotions of individual and sets of selected equipment types that are most appropriate and practicable for the modest house-and-grounds.

(3) Increased understanding, knowledge and use on the part of more members of the lighting profession, not only of the outdoor lighting equipments, but of the integration of appropriate lighting techniques with the fundamentals of tasteful and good design of home grounds.

Acknowledgments

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2. Eckbo, Garrett: *The Art of Home Landscaping*, F. W. Dodge Corp., New York, N. Y., 1956.
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Deadline for Ballots — May 26

Exercise your privilege to vote in the election of National and Local IES Officers. Your ballots reached you early this month and, to be counted, must be received by the General Secretary, at headquarters, not later than May 26.

Figure 1. Living room area.

De Luxe Transformations—

No reader of lighting literature needs to be told that fine lighting befits the fine appointments of a fine home. Model homes have demonstrated the possibilities to the public many's the time (see page 203). Some of these possibilities have been applied, in the two homes shown here, greatly to the enhancement of the areas involved.

Living Room-Kitchen

This is a re-built area, now 22 feet by 20 feet. The space formerly consisted of a dining room, kitchen, breakfast nook and porch, a la 20's. Redesign of both construction and lighting has transformed it to a modern combination living room and kitchen.

There were problems. The porch and breakfast nook, for instance, had a lower ceiling height, which was accentuated by the installation of a 10-inch steel beam, which was necessary for support after the removal of the partitions. Lighting the former breakfast nook and porch area was further complicated by the fact that this area was under a flat roof and didn't have sufficient space to recess anything other than a very shallow luminaire (less than 5 inches in height). What had previously been the kitchen, moreover, was illuminated by a two-lamp 40-watt louvered troffer which had to remain in place. With the new order, the troffer would now be visible from any point in the greatly enlarged space — a possible source of high brightness contrast between light source and ceiling.

The solution is shown in the photographs. Decorative and functional illumination for the former porch and breakfast nook area is accomplished by the installation of cornices over the two picture windows, supplemented by a 150-watt shallow recessed fixture, plus a 200-watt lantern-type luminaire suspended by a pulley over the breakfast table.

The difference in ceiling heights (and the 10-inch steel beam) was overcome by boxing in the beam with the same Samara wood as is used on the wall and on the cove which runs along the entire length of the beam. This cove is lamped with four 40-watt strips using de luxe warm white lamps.

To carry out this same line of light, and to emphasize the only unbroken wall of Samara wood, a valance was installed using two 40-watt and one 30-watt de luxe warm white lamps. This, however,

Lighting design for the Living Room–Kitchen installation was by Harley E. Nichols, St. Joseph Light and Power Co., St. Joseph, Mo., winning for him third prize in the St. Louis Section's MMILJ contest. The Recreation Room is the design of William C. Kuhnke, Wisconsin Electric Power Co., Milwaukee, Wis. This was an entry in the national MMILJ contest, having won first prize in both the Milwaukee Section and the Midwestern Regional contests.

Figure 2. Cornices and valance.

Figure 3. Kitchen and dinette area.

With Light

Figure 4. View through window at night.

created another problem. Because of the doorway (see Fig. 2) anyone walking through the doorway could see down the length of the valance and be exposed to the brightness of the bare lamps and strips. A plastic shield with a $\frac{3}{8}$-inch opening removed this objectionable feature.

The brightness difference in the area adjacent to the already-existing two-lamp 40-watt troffer was minimized by installing a planter on top of the cabinets which form a partial partition between the kitchen and living area. The planter itself is rendered still more decorative with light — a 40-watt de luxe warm white lamp is centered within it. To further balance this brightness ratio, and to provide a higher level of light for dining, two 150-watt recessed louvered spots using PAR floods were installed. Additional light sources in this area include a 150-watt R40 flood behind the soffit over the sink; a 15-watt fluorescent cabinet light under the work-area cabinets; a 75-watt R30 flood to illuminate the barbecue pit. A 40-watt T8 showcase reflector lamp is under the range hood. This is so positioned that the light reflected from the silver in the lamp to a polished aluminum reflector helps to diffuse the light and still provide ample illumination on the range top.

In the living-room area, the picture window opens to an attractive patio and garden area. For nighttime enjoyment, the indoor-outdoor brightnesses are more nearly equalized by illumination of the outside view. A cluster of three 150-watt PAR floods light the patio and yard area.

For the rest of this room, the owners particularly wished to avoid portable lamps. As will be seen in the photograph, the coves and recessed louvered spots provide the illumination for such activities as TV viewing and reading, as well as dining and cooking. Average general illumination level is 30 footcandles.

De Luxe Transformations — With Light

Bar area, with recessed downlights, which follow the contour of the bar, and black-light lamp in paracyl reflector unit recessed in ceiling.

Recreation Room

This area, in the basement of a Milwaukee home, is not "rebuilt." In fact the house is brand new. But the lighting did transform the windowless basement to a flexible play area used for cards, pool, cocktail parties, dancing and the children's play room.

This multiple purpose for the room was, of course, one of the lighting problems. Another was the wish of the owner to do all the construction himself, and still another his wish to avoid portable lighting equipment entirely — the thought being that it could be readily damaged.

Pierced wooden valances provide a feeling of spaciousness in the area which has no windows, as well as adding a decorative touch. They use two 40-watt rapid-start lamps on a dimmer control, behind each two valance boards. Four 75-watt R30 lamps in recessed units light the pool table. These "pool table units" are also controlled by dimmers.

The 9-inch ceiling off-set (part of the ceiling was furred down because of ceiling obstructions) is lighted with a continuous row of five 40-watt rapid-start lamps placed in back of decorative translucent plastic. These also are on dimmer control. Also dimmer controlled are the three 30-watt R20's in small aperture recessed downlights which follow the contour of the bar. At the back of the bar, a 40-watt rapid-start black-light lamp in a paracyl reflector unit recessed in the ceiling lights a black light picture. This shape reflector directs light uniformly over the back wall as well as shielding the ultraviolet from direct radiation.

The five dimmer controls provide a flexibility for lighting the multiple nature of the room's purpose, all from a "built-in" system as desired by the owner.

Pool table area, with pierced wooden valances and R30 lamps in recessed ceiling units, on dimmer control.

Lighting On Display In Model Homes

New ideas and new techniques in residence lighting frequently are introduced to the general public by installations in model homes, where the prospective home-owner can see their effectiveness and potentialities in actual use. The ideas displayed in these four model homes made them all entries in IES Section or Chapter contests for My Most Interesting Lighting Job, Class I.

FLEXIBILITY was the challenge in design of lighting for a low-to-medium priced home in Greensboro, N. C., where all interior walls except those around the baths and kitchen are movable storage walls. Reasoning behind this was the architects' belief that today's homes should be suitable for a changing and growing family — for the young couple with no children, the same couple with perhaps two or three children, and later on the older couple expecting visiting grandchildren.

The lighting had to be adequate for each room in each room arrangement, but it was in no way to interfere with the various positions in which the walls might be placed. Some of the techniques devised to accomplish this are shown in the entry and study, the living room and the bedrooms.

An off-center 150-watt recessed fixture highlights a decorative screen between the entry and the study. General lighting in the study is from a valance, using two-lamp units with 40-watt warm white de luxe fluorescent lamps. All the portable lamps in the house use three-way R40 lamps, personally installed by the lighting designer.

In the living room–family room area, valance lighting is used again. Two valances on separate switches flood the glass wall, separated in the middle by a space of three inches — the width of the folding partition track. A louvered directional 150-watt spotlight is focused on the fireplace.

The children's bedroom and play area can be divided by a folding partition. Specially designed plywood coves are mounted back to back about six

Entry and study.

Living room.

Children's bedroom and play area.

Vanity with soffit.

inches apart on either side of the partition track. The coves have ¼-inch perforations in the bottom for some downlight. Walls of the room are of the movable storage type.

In the master bedroom, the vanity has its own lighting unit, and wherever the vanity may be moved the soffit goes along. Valances on opposite sides of the room provide general lighting.

Lighting designed by Betsy Doughton, Home Lighting Consultant, Duke Power Co., Charlotte, N. C. This installation placed second in Class I of the Tar Heel Section's contest for MMILJ.

THE "model home" on Buffalo Ridge, in Cheyenne, Wyo., is also the home of George Cole, a general contractor, who uses his own house as an example in showing prospective customers the latest in building and lighting. For instance, he has five planters in the house, each with a different type of lighting. Dimmers are used extensively as are different colors of light for different areas and materials. Combinations of incandescent and fluorescent sources are used for highlighting and area lighting. It is the conviction of this contractor that homes should be as interesting and as beauti-

Glass-walled facade shows dramatically lighted interior —from left to right: family room, kitchen, living room.

Entire periphery of the house is lighted by 100-watt yellow downlights.

Each of the four perforated suspended downlights over the family dining table is specially tinted to accentuate the different pastel colors of the lamps. Large-area 2- by 2-foot plastic luminaires, each containing six 20-watt warm white de luxe lamps, and under-cabinet fluorescent units provide working light. Pastel gold, semi-recessed units, on a dimmer, accent the gold thread in the draperies.

Living room (left) also has semi-recessed perforated fixtures with gold-colored lamps to dramatize the draperies on the long window wall. These are spaced every four feet along the wall. A cluster of six frosted glass cylinders, containing five 25-watt enameled colored lamps and one 15-watt white lamp of approximately equal brightness, is suspended from the ceiling.

ful at night as they are during the daylight hours.

Lighting designed by Fred H. Rosenquist, Public Service Co. of Colorado, Denver, Colo. This installation won first prize in the Inter-Mountain Region's 1958 contest, Class I, MMILJ, having previously won first in the Rocky Mountain Section.

Valance in the family room provides illumination for the organ as well as highlighting the fireplace and paneled wall. The semi-recessed downlights near the curtains have pink-colored lamps for a change of pace and to provide the background for a casual atmosphere.

Typical bedroom has valance lighting over the bed, providing both downlight for reading in bed and uplight for general room illumination.

TYPICAL of the problems inherent in residence lighting are those presented by the Millbrae model home in California. Not only the technical problems of meeting IES recommended practices, but also the personalities involved, who must be catered to. The builder is interested from an economy standpoint; the architect wants the lighting to conform to his designs; the electrical contractor in many cases shies away from any new type applications; the interior decorator wants nothing to mar his decor; the fixture salesman may have still other fish to fry; and there is always the woman, someone's wife, who has a feminine point of view.

Perhaps the area where this problem was most critical was the downstairs playroom. The room is over 40 feet long and 18 feet wide with a ceiling height of 12 feet. For the purposes for which the room was to be used, it seemed that a broad light source would do the best job — a luminous ceiling, or to be specific two luminous ceilings, 10- by 15-foot in size in each end of the room.

The builder didn't want the expense of such an installation; the electrical contractor had never put one in and was not enthusiastic about beginning; the wife of the builder had never seen one in a home and was doubtful.

The builder's reluctance was overcome by getting the ceiling subsidized. The electrical contractor was pacified by reassurances of the experience he would get and that competent engineers were on hand to help if necessary. It was pointed out to the wife that this installation would probably be the largest installation of its kind in the area — and for a model home it would be an attraction. The luminous ceiling went in.

Because of the sloping ceiling in the living room, ceiling-mounted fixtures were not wanted, yet some downlight was needed to supplement the cove. The outstanding feature in the room is the fireplace, made of petrified rock from a dry lake bottom in Texas. The rock contains remains of marine life and is of a deep pink color. The recommendation was made to dramatize this characteristic with colored downlight from recessed units three feet from the fireplace. This appeal to concentrate attention on the fireplace was accepted, and the recessed lights went in.

The dining room also had cove lighting, but needed downlighting. This time the appeal was made along glamor lines, pointing out that incandescent light was needed to pick up the glitter and sparkle of the table settings and to put highlights in the hair and eyes of people. Various types of new ideas in hanging fixtures were presented, and the idea was accepted.

In the master bedroom, a 12-foot cornice, of three 4-inch strips, and four portable lamps supply general lighting. Two recessed downlights over the head of the bed add "reading-in-bed" illumination. The decorative frieze of the cornice is carried on around the tops of the walls for continuity in appearance.

Other areas in the house were lighted as shown in the plan view drawing. The finished home has 110 lighting units — 57 fluorescent fixtures, 43 incandescent and 10 portable lamps. Over 55,000 people went through it when it was on display.

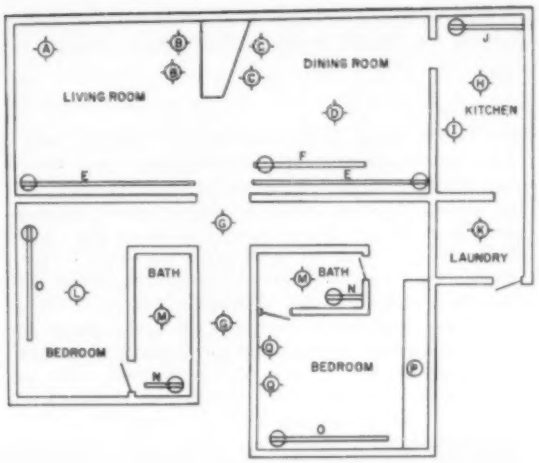
It was sold; the builder and his wife bought it for themselves.

Lighting designed by Robert Haskell, Residential Lighting Specialist, Pacific Gas and Electric Co., San Francisco, Calif. This installation won first prize in the 1958 contest of the Golden Gate Section for MMILJ, Class I.

In the downstairs playroom, 15- by 10-foot luminous ceilings in each section use a total of 32 fluorescent strips. The four strips in the center of the panels are blue, gold, red and pink. A recessed downlight is focused on the fireplace. Portable lamps, not shown in photo, are also used.

Living room and dining room
(See plan view)

A — Recessed downlight.
B — Recessed eye-ball units with 150-watt pink PAR38 lamps.
C — Recessed eye-ball units with 150-watt blue PAR38 lamps.
D — Suspended ceiling fixture of seven copa-shell elongated bubbles, each with a 40-watt lamp.
E — 40-watt rapid-start cove lighting on dimmers.
F — 12-foot valance over bookcase; three 4-foot strips diffused with photographically treated glass.



Areas not shown in photos

G — Hall lights.
H — Surface-mounted area unit with plastic diffuser.
I — Light over range.
J — Soffit, two rows, 8-foot long.
K — Surface-mounted area unit with plastic diffuser.
L — Ceiling fixture.
M — Ceiling fixture.
N — Soffit, two rows of 48-inch 40-watt rapid-start fluorescent.

Master bedroom

O — 12-foot long cornice, three 40-foot strips.
P — Pull chain.
Q — Recessed PAR38 spots.

Nighttime living on the terrace is made possible and pleasant by wall-mounted fixtures surrounding the patio, garden lighting for the shrubbery and all-weather outlets to work a barbecue spit or power a TV set.

FLOOR plan of this Portland, Ore., home covers 2200 square feet, excluding the garage area. Total lighting load is 7800 watts. Basing the calculations on lumen count, however, instead of wattage per square foot, an average of 60 lumens per square foot of area was obtained — well within the standards of the IES Recommended Practice.

During the 30-day demonstration period, nearly 31,000 visitors were exposed to the lighting. Installation was designed by Mrs. Grace C. Shoeni, Home Lighting Advisor, Portland General Electric Co., Portland, Ore., and won first prize in the Oregon Section's contest for MMILJ and later won first in the Pacific Northwest Region's contest.

General illumination in the kitchen is by a luminous soffit around three walls. On inside walls the 40-watt T12 de luxe cool white lamps are mounted on the wall to direct light out through the vertical plastic shielding. At the window area, the same type lamp is mounted on the ceiling to direct light both outward and downward over the sink. Vertical shielding is by ⅛-inch Plexiglas with a transmission factor of 80 per cent, used in four-foot lengths, eight inches wide. The horizontal shielding at the window area is a strip of aluminum "honeycomb" diffuser in ¼-inch cell size, providing 60-degree light cut-off. Under-cabinet lighting is from 20-watt T12 fluorescent lamps and there are two 60-watt incandescent lamps in the range hood over cooking units.

The family room is adjacent to the kitchen, with a snack bar across from the serving bar. Cornices are used on three walls for general lighting, tying in with the kitchen lighting, which is visible across the snack bar. Four 40-watt T12 lamps are used on the 20-foot side walls and three on the 16-foot end wall, centered on each wall, with both side and bottom shielding. End spaces are filled in with plywood panels to form an interesting pattern. Sunshine grouping above the lounge at one end of the room is composed of one pull-down sunlamp fixture controlled by a timer switch and three recessed ceiling units consisting of a second sunlamp and two infrared lamps.

Predetermination of Luminances By Finite Difference Equations

By PHILIP F. O'BRIEN
JAMES A. HOWARD

Luminous flux transfer in an enclosure may be described by a system of linear simultaneous equations which are a finite difference representation of the Fredholm integral equation. Many techniques of numerical analysis, including analogue and digital computers, are applicable to the solution of these equations. The development of this method for the analysis and synthesis of lighting systems is now being prosecuted actively on a world-wide basis. Truncation errors, an inherent feature of the finite difference equations, can be reduced to acceptable levels. Additional numerical methods need to be explored for applicability to the analysis of lighting systems.

Predetermination and Synthesis

The essence of illuminating engineering is the synthesis of lighting systems that will provide the seeing occupant with a luminous environment in which he can perform at a certain level of accuracy and comfort. Comfort, as used here, is understood to include the aesthetic as well as the physiological and psychological components. When the engineer has expressed the design criteria of a proposed lighting system in terms of a luminance pattern based on the fundamental data of visual psychophysics, he must formulate a physical system which will provide this required luminance pattern. The process of formulation or synthesis of lighting systems may be accomplished with little conscious organization of the relationships between the system parameters, and this is the art-of-engineering method often employed by the experienced designer. But regardless of the method of synthesis, the lighting system which is initially conceived by the designer must be tested to determine if a suitable match exists with the design criteria. This test for compatibility with the required system performance is usually accomplished when the design is in the paper and pencil stage. In the terminology of the International Commission on Illumination (C.I.E.),[1] the quantitative analysis of lighting systems is concerned with the "predetermination* of illumination and luminance." As suggested by its title, this paper is concerned with predetermination using a particular form of the fundamental equations of radiation transfer.

Luminous Transfer Systems

The objectives of the predetermination of luminance patterns may be described in terms of the transfer functions of the physical and psychophysical systems which characterize all luminous design problems. In the block diagram of Fig. 1, the physical system is specified as an enclosure with a certain geometry and surface reflectance distribution. Luminous flux with some spectral and directional properties enters the room at various locations and excites the room which responds with a particular luminance and illumination pattern. In short, the room couples the light source to the luminance distribution. For each mode of luminous excitation or input there is a corresponding set of luminances. In rooms with non-black walls, interreflections of luminous flux cause the coupling of the response-luminance to the excitation-flux to be be a complicated function of the room shape and surface reflectances. The quantitative relationship between excitation and response is termed the transfer function, and in lighting technology has taken the form of the interflectance factor and the coefficient of utilization.

Similarly, the psychophysical system *(i.e.,* the *eye* and associated nervous system) is excited by

*The word "predetermination" was apparently introduced into the lighting literature by J. Dourgnon, in 1928, through his important paper, "Nouvelle methode de predetermination des coefficients d'utilisation," *Revue Generale de l'Electricité* (Paris), Vol. 23, p. 271 (1928).

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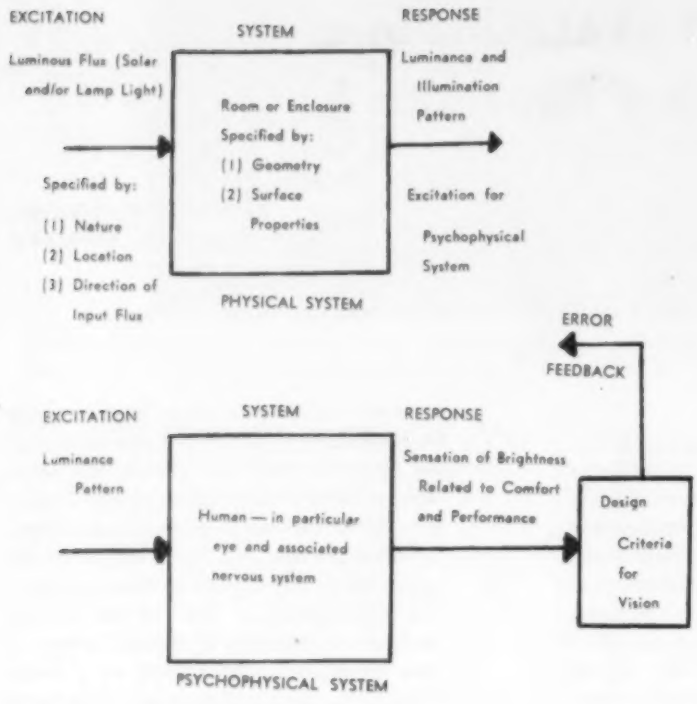

Figure 1. Relation between physical and psychological systems of a lighting design problem.

the physical luminance pattern and responds with the sensation of brightness and associated levels of task performance and comfort. The excitation of the psychophysical system also includes the detailed characteristics of the task *(e.g.,* contrast, time of viewing, visual size), but these are controlled in the experimental determination of the psychophysical transfer functions. Visual transfer functions are usually expressed in terms of the value of physical stimulus which will evoke a threshold response such as contrast threshold at various adaptation levels.

An inspection of Fig. 1 reveals that the response of the physical system is the excitation of the psychophysical system. In addition, the required visual responses are the design criteria for the overall luminous environment. The complexity, but unity, of the total situation is related to the linking of the physical and psychophysical systems. In practice the designer defines a room and its excitation *(e.g.,* luminaires, fenestration) which, based on experience, he believes will satisfy the visual design criteria. If the predetermined luminance pattern produces a visual response different from that desired, this error *(e.g.,* as in a control system) is feedback information that the designer uses to adjust the luminous inputs and physical properties of the room to obtain, more closely, the required luminance pattern.

In the lighting literature, the analysis of lighting systems or the predetermination of luminance patterns based on a particular set of luminous inputs, room geometry and surface reflectances has been considered almost to the exclusion of synthesis. Referring to Fig. 1, the synthesis of a lighting system is concerned with selecting the luminous excitation, geometry and luminous properties which will yield the required response or luminance pattern. Although synthesis is clearly the major contribution of the lighting designer, the "designed appearance" method of Waldram[2] appears to be the only recent approach to this problem. However, high speed digital computers and the Luminous Analogue Computer[3] are recently developed aids to lighting calculation that should allow a more systematic approach to lighting synthesis.

Analytical Methods

More than thirty years ago, Yamauti[4] and Buckley[5] recognized that the fundamental equation of radiant flux transfer was an expression of conservation of flux which can be written as:

$$L_1 = L_{01} + \rho_1 E_1 \qquad (1)$$

$$L_1 = L_{01} + \frac{\rho_1}{\pi A_1} \int_{A_1} \int_{A_n} L_n \frac{\cos\theta_1 \cos\theta_n}{r^2_{1-n}} \, dA_n \, dA_1 \qquad (2)$$

where:

L_1 = total average luminous emittance of finite surface A_1 including all interreflections (lumens/foot^2)

L_{01} = initial or "input" luminous emittance of surface A_1 excluding interreflections (lumens/foot^2)

ρ_1 = luminous reflectance of surface A_1

E_1 = total illumination of surface A_1 including interreflections (lumens/foot^2)

L_n = total luminous emittance, including interreflections, of a surface element dA_n which may be viewed directly from A_1 (lumens/foot^2)

$\cos\theta_1, \cos\theta_n$ = cosines of the angles between the normals to surface elements dA_1 and dA_n and the ray connecting these elements

r_{1-n} = length of ray connecting the surface elements dA_1 and dA_n.

The solution of Equation (2) is obtained when luminous emittance L_n is known for all differential areas which define the room surfaces. In terms of the physical system of Fig. 1, L_{01} is the stimulus that is linked to the response L_n by the system geometry and porperties ρ_1. If Equation (2) were written in perfectly general form, L_1 would be the luminous emittance of the differential element dA_1 and the terms L_o and ρ would be some function of the location on the room surfaces.

Only for simple geometries and stimulus conditions L_o is Equation (2) in a form that is immediately integrable. As an example of Equation (2) (Fredholm's equation of the second kind) applied to a simple geometry, Moon[6] has obtained the well-known integrating sphere relationship by direct integration. When the geometry is as complicated as a circular cylinder, the kernel of the integral term of Equation (2) is not integrable in closed form without some modification. Buckley[5] showed that exponential functions which are approximations of the kernel will allow the solution of Equation (2). Moon and Spencer[7] have further developed the method of kernel approximation and have made available to the lighting designer a valuable set of luminous emittance data which describe lighting in symmetrical rooms.

Finite Difference Equations

Another approach to the solution of the Fredholm integral, Equation (2), is to write a set of finite-difference equations which also allow an approximate solution. Yamauti[4] seems to have been the first to suggest the use of the finite difference equation method. By this method the following set of equations are obtained:

$$\begin{aligned}
\frac{1}{\rho_1} L_1 - F_{1\to 2} L_2 \ldots - F_{1\to n} L_n &= \frac{L_{01}}{\rho_1} \\
- F_{2\to 1} L_1 + \frac{1}{\rho_2} L_2 \ldots - F_{2\to n} L_n &= \frac{L_{02}}{\rho_2} \qquad (3) \\
\vdots \quad \vdots \quad \vdots \quad \vdots & \\
- F_{n\to 1} L_1 - F_{n\to 2} L_2 \ldots + \frac{1}{\rho_n} L_n &= \frac{L_{0n}}{\rho_n}
\end{aligned}$$

where:

$L_1, L_2, \ldots L_n$ = total luminous emittance of finite areas $A_1, A_2, \ldots A_n$ (lumens/foot^2).

$$F_{1\to n} = \frac{1}{\pi A_1} \int_{A_1} \int_{A_n} \frac{\cos\theta_1 \cos\theta_n}{r^2_{1-n}} \, dA_n \, dA_1. \qquad (4)$$

The quantity $F_{1\to n}$ is the shape modulus, a dimensionless measure of the shape of A_n relative to A_1. Specifically, $F_{1\to n}$ is the fraction of diffuse flux leaving finite area A_1 that is directly intercepted by finite area A_n. The symmetric property ($A_n F_{n\to m} = A_m F_{m\to n}$) of the shape modulus aids the formulation of the finite difference equations. An excellent compilation of shape moduli has been prepared by Hamilton and Morgan[8] as a contribution to the analysis of radiant power-transfer systems, but the data are equally applicable to the analysis of lighting systems. In addition, several new contributions to shape modulus calculations have recently been reported by Gouffe.[9] In a recent paper, O'Brien[10] has reviewed some experimental and graphical methods for the determination of the shape modulus.

Although the finite difference equations were suggested by Yamauti[4] in 1926, this numerical method for the solution of the Fredholm integral has been developed in the lighting literature only recently. For example, Caracciolo[11] (Italy) has represented a square room with three equations similar to Equation (3) and has plotted the resulting interflectance factors as a function of the room index. Dourgnon[12] (France) has also represented square rooms by three equations and has solved the equations using a high-speed digital computer. Phillips[13] (Australia) has solved the same problem with a digital computer using an iterative method for the solution of the linear simultaneous equations. Zagustin and Centeno[14] (Venezuela) suggest a paper and pencil approach to the iterative solution of the finite difference equations. O'Brien and Ross[15] have represented a square room by 14 simultaneous equations and have solved the system of equations using the Bendix G-15D General Purpose Digital Computer. In short, the last five years has seen a rapid revitalization of the finite-difference method suggested by Yamauti thirty years ago.

The Luminous Analogue Computer

In addition to paper and pencil and digital computers, another aid to numerical analysis, the analogue computer, has been applied by O'Brien[16] to the solution of the finite difference equations. By algebraic manipulation, Equation (3) can be transformed to Kirchhoff's node equation for flux transfer as follows:

$$\begin{aligned}
&\frac{L_1-L_2}{1/A_1F_{1\to 2}}+\ldots\frac{L_1-L_n}{1/A_1F_{1\to n}}=\frac{[L_{01}/(1-\rho_1)]-L_1}{\rho_1/(1-\rho_1)A_1}\\
&\frac{L_2-L_1}{1/A_1F_{1\to 2}}+\ldots\frac{L_2-L_n}{1/A_2F_{2\to n}}=\frac{[L_{02}/(1-\rho_2)]-L_2}{\rho_2/(1-\rho_2)A_2}\\
&\qquad\vdots\qquad\qquad\qquad\vdots\qquad\qquad\qquad\vdots\qquad\qquad (5)\\
&\frac{L_n-L_1}{1/A_1F_{1\to n}}+\ldots\frac{L_n-L_2}{1/A_2F_{2\to n}}=\frac{[L_{0n}/(1-\rho_n)]-L_n}{\rho_n/(1-\rho_n)A_n}.
\end{aligned}$$

Equation (5) is recognized as Kirchhoff's node equation if the luminous emittances in the numerators of each fraction are regarded as potentials and the denominators, which are composed of geometry and property terms, are regarded as resistances. Equation (5) describes a non-planar network whose nodes are at a potential *(e.g., L_1, $L_2 \ldots L_n$)* which is directly proportional to the total luminous emittance including all interreflections. The terms on the left of Equation (5) show that each node is connected to every other node through a resistance $1/A_nF_{n\to m}$. If the surfaces exchanging luminous flux are relatively large and in proximity, the resistance $1/A_nF_{n\to m}$ approaches $1/A_n$. Inspection of the dimensions of Equation (5) indicates that the current or through variable is luminous flux or lumens. The terms on the right side of Equation (5) represent sources or sinks for luminous flux depending upon the relative value of the driving potential $L_{on}/(1-\rho_n)$.

To aid the solution of Equation (5), an electrical analogue computer, the Luminous Analogue Computer, has recently been constructed in the Department of Engineering, University of California, Los Angeles. This machine is composed of a variable resistance network and electric power supplies that are interconnected according to Equation (5). In the broad sense, the Luminous Analogue Computer is merely another artifice of numerical analysis for the solution of the finite difference equations. However, there are some unique features of the analogue approach which seem to favor its use over other numerical methods. The features are: (1) the machine is highly flexible and can be quickly set to represent a room with any initial division of flux, an arbitrary reflectance distribution, and any geometry within the capacity of the machine (Note: the University of California machine has a capacity of ten surfaces), (2) the Computer is a structural analogue so that the settings of the resistances which represent the geometry and reflectances are easily understood and can be related to everyday experience with lighting systems, (3) synthesis of the required initial flux division and reflectance distribution which will give the total design luminance pattern can be accomplished quickly by simply adjusting the computer controls until the desired pattern is obtained (Note: this is the "designed appearance" method of J. M. Waldram[2] of Great Britain), and (4) the initial cost of the analogue computer is about one per cent of the cost of the smallest suitable general purpose digital computer. Briefly, the Analogue Computer is an easily understood model of the lighting system.

Poisson's Equation Applied To Luminous Transfer Problems

Another feature of the finite difference expansion, Equation (5), of the Fredholm integral is that it can be shown to be similar to the finite difference expansion of Poisson's equation. Much progress in engineering has been based on the analogous performance of systems described by the same fundamental partial differential equation. A luminous field where the internal excitation is a function of the space coordinates *(x, y, z)*, the field potential L, and a scalar quantity ρ may be represented by Poisson's equation of the following form:

$$\nabla^2 L = f(x, y, z, L, \rho). \qquad (6)$$

A finite difference expansion of Equation (6) in three dimensions and in terms of potential and resistance parameters R_{nm} at node 1 in the field is:

$$\frac{L_1-L_2}{R_{12}}+\frac{L_1-L_3}{R_{13}}+\ldots\frac{L_1-L_7}{R_{17}}=i(x, y, z, \rho_1, L_1). \qquad (7)$$

The current term on the right side of Equation (7) can be represented by a potential difference divided by a resistance which is a function of x, y, z and ρ_1:

$$\frac{L_1-L_2}{R_{12}}+\frac{L_1-L_3}{R_{13}}+\ldots\frac{L_1-L_7}{R_{17}}=\frac{L'_1-L_1}{R(x, y, z, \rho_1)}. \qquad (8)$$

Equation (5), the finite difference expansion of the Fredholm integral, shows an arbitrary number *(n)* of resistance elements connected to node 1, while Equation 8, a three-dimensional finite difference form of Poisson's equation, shows only seven elements. Because the form of Equations 5 and 8 is similar, luminous flux transfer in rooms may be regarded as a multidimensional problem. In practice, the number of nodes is increased until gain in accuracy is matched by the complexity of a large

network. In addition, the internal excitation (right hand term of Equation 8) can be conceived as a current source or sink to account for the initial division of flux and the interreflections within the enclosure.

The Truncation Error

The Fredholm integral, Equation (2), and its finite difference form, Equations (3) and (5), describe idealized or mathematical models whose performance may differ from physical, or real, lighting systems. Some characteristics of the idealized model whose performance is given by Equations (3) and (5) are:

(1) The reflection and emission of all flux is perfectly diffuse.

(2) The excitation flux and the reflectances are not functions of wavelength over the interval chosen.

(3) Steady state conditions exist.

(4) A non-scattering and non-absorbing medium fills the space between the surfaces.

(5) The size of the enclosure is large compared to the wavelength.

(6) The flux is initially, and at each reflection, uniformly distributed over each of the finite surface elements.

Postulate Number 6 concerning uniformity of flux over finite areas causes idealized models, represented by a few large areas, to exhibit luminance patterns slightly different from a model with many smaller areas. A mathematical model whose walls are entirely represented by differential areas exactly meets the conditions of Postulate Number 6. The use of finite areas gives rise to the truncation error or the difference between the exact solution of the finite difference equations and the exact solution of the differential representation such as given by the general form of the Fredholm integral.

In order to discover the magnitude of the truncation error in a lighting system the infinitely long hallway (*i.e.*, height = 2; width = 1; $k_r = 1.0$), for which Spencer[17] recently obtained an exact solution, was analyzed with the walls of the room represented by one, two and four areas or equal sections between the floor and ceiling. This long hallway is depicted in Fig. 2 for the case of one uniform wall section.

To obtain sufficient accuracy, the finite difference representations of the infinite hallway were programmed for the Bendix G-15D Digital Computer. A punched tape routine (Note: Maisie is the code name of the program) is available with the G-15D for the solution of linear simultaneous equations so that the programming simply involved computation of shape moduli.

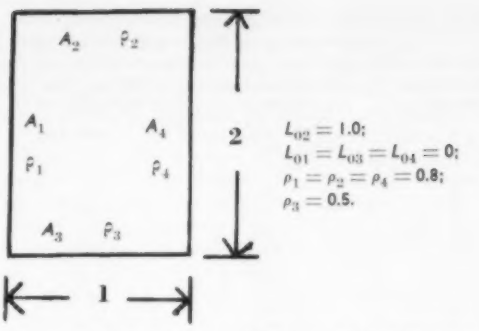

Figure 2. Infinitely long hallway with luminous ceiling.

Because the hallway has a symmetrical excitation (luminous ceiling) and reflectance distribution, the average emittances of both walls of the hallway will be equal at the same level. This symmetrical condition permits a reduction in the number of equations describing the hallway from $2(n+1)$ to $(n+2)$ where n is the number of elements into which the wall is divided.

The manner in which the equations for the hallway are reduced in number can be shown by writing the finite difference equations for the hallway of Fig. 2.

$$\begin{aligned}
(1/\rho_1)L_1 - F_{1\to 2}L_2 - F_{1\to 3}L_3 - F_{1\to 4}L_4 &= 0 \\
-F_{2\to 1}L_1 + (1/\rho_2)L_2 - F_{2\to 3}L_3 - F_{2\to 4}L_4 &= L_{o2}/\rho_2 \\
-F_{3\to 1}L_1 - F_{3\to 2}L_2 + (1/\rho_3)L_3 - F_{3\to 4}L_4 &= 0 \\
-F_{4\to 1}L_1 - F_{4\to 2}L_2 - F_{4\to 3}L_3 + (1/\rho_4)L_4 &= 0
\end{aligned} \tag{9}$$

By symmetry and equal wall reflectance:

$$\begin{aligned}
F_{4\to 1} &= F_{1\to 4} & L_4 &= L_1 \\
F_{4\to 2} &= F_{1\to 3} & \rho_4 &= \rho_1 \\
F_{4\to 3} &= F_{1\to 3}
\end{aligned} \tag{10}$$

Substituting Equations (10) in Equation (9) and simplifying yields a new set of equations describing the hallway:

$$\begin{aligned}
(1/\rho_1 - F_{1\to 4})L_1 - F_{1\to 2}L_2 - F_{1\to 3}L_3 &= 0 \\
-2F_{2\to 1}L_1 + (1/\rho_2)L_2 - F_{2\to 3}L_3 &= L_{o2}/\rho_2 \\
-2F_{3\to 1}L_1 - F_{3\to 2}L_2 + (1/\rho_3)L_3 &= 0.
\end{aligned} \tag{11}$$

As shown in Equations (9) and (11), the number of equations describing the enclosure has been reduced. This technique is useful in analyzing lighting systems exhibitiing symmetry as in this problem. If the Luminous Analogue Computer had been employed only $(n+2)$ instead of $2(n+1)$ nodes would have been necessary to describe the problem so that $2(n+1-(n+2) = n$ nodes would be conserved.

In Table I the relative luminous emittances of the hallway surfaces are reported for one, two, and four equal wall divisions or sections. According to the notation of Fig. 2, subscripts 1, 2, and 3 refer to

TABLE I — Spencer's Exact and the Approximate (*i.e.*, based on finite difference equations) Distribution of Light in a Very Long Room with a Luminous Ceiling. $k_r = 1.0$ $\rho_1 = \rho_2 = 0.8$ $\rho_3 = 0.5$

Number of Wall Sections	Relative Luminous Emittance	Distance from Ceiling (Units)	Exact Emittance	Approximate Emittance	Truncation Error Per Cent
1	L_1/L_{c2}	1.00	0.5166	0.5329	+3.15
1	L_2/L_{c2}	—	1.4514	1.3952	−3.87
1	L_3/L_{c2}	—	0.3499	0.3682	+5.23
2	L_1/L_{c2}	0.50	0.6523	0.6447	−1.17
2	L_1/L_{c2}	1.50	0.4276	0.4335	+1.38
2	L_2/L_{c2}	—	1.4514	1.4306	−1.43
2	L_3/L_{c2}	—	0.3499	0.3532	+0.95
4	L_1/L_{c2}	0.25	0.7429	0.7276	−1.93
4	L_1/L_{c2}	0.75	0.5785	0.5740	−0.78
4	L_1/L_{c2}	1.25	0.4675	0.4650	−0.53
4	L_1/L_{c2}	1.75	0.3944	0.3926	−0.46
4	L_2/L_{c2}	—	1.4514	1.4442	−0.49
4	L_3/L_{c2}	—	0.3499	0.3491	+0.23
8*	L_2/L_{c2}	—	1.4514	1.4488	−0.18

*Extrapolated value.

the walls, ceiling and floor, respectively. With each approximate value the corresponding exact value as computed by Spencer[17] (Note: in some cases the exact wall emittances were computed by linear interpolation of Spencer's values) is shown. As shown in Table I, the per cent difference between the exact and approximate emittances, or the truncation error, is significantly reduced at each doubling of the number of wall sections (Note: in analogue terminology this would correspond to halving the mesh interval). The truncation errors for the case of four wall sections are small enough to make further division of the room surfaces seem unnecessary. The errors reported by Spencer for this case using the Interflection Method are about ten times larger than the errors for the four-section wall. One exception to this is the luminous emittance of the wall near the ceiling. The high gradient of wall emittance near the ceiling suggests that the error could be reduced by a smaller mesh interval at this location and, perhaps, a larger interval near the floor where the emittance gradient is less could be used.

Extrapolation Technique

An indication of the magnitude of the luminous emittances for the eight-wall-section case can be obtained by using an extrapolation method such as suggested by Liebmann[18] and Culver.[19] The luminous emittance of the ceiling can be approximated from the two- and four-section solutions by the relation:

$$L_2^8 = L_2^4 - \tfrac{1}{3}\,(L_2^2 - L_2^4) \qquad (12)$$

where:

L_2^8 = relative luminous emittance of the ceiling for the case of eight wall sections

L_2^4 = ceiling emittance for the four-wall-section case

L_2^2 = ceiling emittance for the two-wall-section case.

The extrapolated ceiling emittance for the eight-wall case is shown in Table I to exhibit a truncation error twenty times smaller than the one-section wall case.

Conclusion

The predetermination of luminance patterns and the reverse process of synthesization of luminous systems are necessary components of lighting design. The professional lighting designer understands and utilizes the rapidly growing storehouse of knowledge related to the analysis and synthesis of lighting systems. Although the finite difference representation of lighting systems has been known for at least thirty years, this method is just now being developed actively on a world-wide basis. The finite difference equations are well suited to solution by modern aids to numerical analysis, such as the analogue and digital computers.

Many important analytical techniques which can be applied profitably to the representation of luminous systems exist in other disciplines of engineering and science. The translation of these methods into the context of lighting technology is required. Some of these important areas may be: (1) the use of iterative methods for the solution of the finite difference equations, (2) the Monte Carlo[20] method applied to non-diffuse reflection and non-isotropic scattering as in fog, (3) application of Kron's method of tearing[21] to the reduction of large networks which represent complicated but loosely coupled lighting systems and (4) additional study of resistance analogue solutions of photic or luminous field problems.

By the aggressive acquisition and exploitation of modern methods of numerical analysis, the professional illuminating engineer can lead the other practitioners of environmental design to a more rational synthesis of integrated and optimum indoor climates for human performance and comfort.

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DISCUSSION

DOMINA EBERLE SPENCER:* The names of O'Brien and Howard are comparatively new to the IES. Their contribution in applying the analogue method to a solution of the basic integral equations of interflection theory by use of the finite difference approach is valuable. However, perhaps due to their comparatively brief association with the Society, they have fallen into several conceptual errors.

They say that the "numerical method . . . has been developed in the lighting literature only recently." May I remind the authors that nearly thirty years ago Moore[1] and Manning and White[2] were applying such methods to just such problems, and in 1934, the finite difference or numerical approach to the interflection problem was treated in Professor Higbie's excellent book.[3] The new thing about the numerical method is not the method, but the proficiency with which it has recently been applied.

The authors also suggest that synthesis of a lighting system is a new idea. The *word* synthesis as applied to illuminating engineering is perhaps new, but the procedure is not. The first application[4] that Professor Moon and I made of the interflection method was to finding what methods could be used to synthesize the optimum luminous environment. We found that for nearly all shapes of rooms, the best way to satisfy the 3:1 adaptation brightness ratio was to make the entire ceiling a source of light. This, as far as we are concerned, was the beginning of luminous ceilings. The practical development of luminous ceilings has merely been a long struggle to realize the synthetic photographs which were exhibited by Professor Moon and myself at the 1946 National Technical Conference. Subsequently, we wrote an entire book on the subject, which the authors cite in their references.

Even though it is called valuable, I hasten to disown "emittance data." The interflection method of lighting calculation provides an analytical method of predicting the interflectance and the brightness distribution in a room. It is interested *not* in the *light cones diverging* from the surfaces which bound the room, but in the lumens per unit area per unit solid angle received by the eye at any point through a *light cone which converges at the receiver*. The fact that the two may be numerically equal in certain special cases is unimportant. The important thing is to specify the concept which one measures with any photoelectric brightness meter such as the Photo Spot or with any visual brightness meter such as the Luckiesh-Taylor. It is very important to grab hold of the significant end of the light cone. If the authors undertake the very commendable task of solving interflection problems with semi-specular surfaces or containing fog, they would do well to think enough about photometric concepts to understand the difference between the visually meaningful concept of brightness and the visually meaningless concept of emittance.

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JEAN DOURGNON:* The authors are kind to recall my study of 1928. This was, to my knowledge, the first use of Professor Yamauti's ideas, given two years before, although, at that time, I did not even know Professor Yamauti's name. In my first paper, February 11, 1928, I used a rather tedious method, but I showed later (on April 7 of the same year) that my method was nothing more than the solution of two linear equations. (Codogone, several years later, used three equations because he included ground reflection.)

It has been explained that calculations assuming uniform direct and reflected flux give the same results as calculations assuming only uniform total flux, since the first case can be imagined to be only a particular case of the second. I must, therefore, disagree with the sixth statement of the section entitled "The Truncation Error."

It is rather interesting to note that Professor Yamauti who, I believe, first wrote about finite difference equations for interreflection problems, apparently did not use them either in his paper before the International Commission on Weights and Measures, "The Black of the Black Body," or in the study he made for the International Congress of Illumination, Paris, 1937, "The Analytical Study of Interreflec-

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tion in Infinite Cylinders," except for a brief reference to my own procedure.

As the authors mention, there are now several of us using finite difference equations. Unfortunately, we are troubled by quite different symbols and methods of presentation. Comparison between the work of the authors and myself seems to be useful. As you know, Committee W3.1.1.1 of the CIE is currently trying to obtain some standardization in this matter.

The main difference between our methods is that I use the flux *received*, while the authors use the flux *sent per unit of area*. The first approach seems more sensible. In fact, we generally use surface elements which are not at all very small, and those surfaces emit or reflect flux. Illuminations or emittances used are not actual values for well specified points, but are mean values, so they are not physical magnitudes that result from mathematical computations.

When the electroluminescent condenser is in routine use, the boundary surfaces may be self-luminous. Since, at the present time, these boundary surfaces are luminous only because they are illuminated, it is much more sensible to use the incident direct flux instead of the emittance that the surface would have if it were self-luminous. It requires a certain amount of *gymnastique de l'esprit* to use the concept of self-emittance. I know, however, that the electric network gives directly only luminances.

The shape modulus $F_{i\to j}$ is just the same as my "facteur de forme q_{ij}. I do not agree, however, with the letter, F, because F generally means flux.[1] Furthermore, I do not understand the direction of the arrow. I know that $F_{i\to j}$ is the part of the flux emitted by i that reaches j. The authors, however, do not use this definition, but instead use the alternative one which is the illumination on i when j has unit emittance. Then, light flows from j to i in the reverse direction of the arrow. The order of the index of the authors is the most suitable for their equation; my order (the reverse) is most suitable for my equation. Note that the authors use the emittance while I use the luminance (in candela per unit area), and on that point I quite agree with them against myself. The authors state that the shape modulus is nothing more than the sky factor. This is only true in a formal way when at least one of the surface elements is truly an infinitely small area. I must say that if we use the original Fredholm method for solving Fredholm's equation, we have to use actual illumination at central points of small areas, and so the sky factor. That procedure is only applicable, however, when the areas are small enough. In practice, illuminating engineers use a small number of surfaces that cannot be assumed to be small in size. In order to avoid this difficult point, they do not use the actual illumination (or emittance) at specified points, but the average illumination (or emittance). This means, in fact, that they use flux on surfaces of finite size.

Table I gives calculated illumination on specified points, but we do not know how these illuminations have been obtained. I assume that the authors did calculate sky factor from these points for the different elements of surfaces, their emittances being computed by their equation (5). If these computations of emittances have been made with the use of shape modulus and not sky factor, as I think might be the case, we would have an example of a mixed elaborated method which should yield a value reasonably close to actual illuminations. This is a point which is worthy of consideration.

I recall that I gave rather a complete review (for the time) of predetermination methods for computation of sky factors in 1934[2] (note that the apparatus quoted in Fig. 22 of the article is not Walsh's but Townsend's) and that I used a physical method of predetermination of shape modulus which seems to give good results.[3]

Those points stated, I would like to give a more precise comparison of our procedures. When we have only two surfaces, i and j, I write that the total flux ϕ_i received by i is equal to the direct flux ϕ_{oi} on that surface i plus the flux $q_{ij}\rho_j\phi_j$ that j flows into i

$$\phi_i = \phi_{oi} + q_{ij}\rho_j\phi_j \dots \qquad (1)$$

In the case of more than two surfaces, we again have the same equation that is written

$$\phi = \phi_o + q\rho\phi \dots \qquad (2)$$

Where ϕ and ϕ_o are the vectors of the total and direct flux respectively received by the n surfaces, q is the matrix of the shape modulus, and ρ is the diagonal matrix of the reflectances.

If we write

$$\phi_o = (1 - q\rho)\phi \qquad (3)$$

we solve the problem in Waldram's way.

If we write

$$\phi = (1 - q\rho)^{-1}\phi_o \dots \qquad (4)$$

the problem is solved in the ordinary way; that is, we try to compute ϕ when ϕ_o is known. The main operation involved in formula (4) is an inversion of matrix which can be done very quickly by electronic digital computers. These computers are very expensive, but it is not necessary to buy one since we need only to give the work to a service facility having these machines. As a matter of fact, the Society "IBM France" has computed for the "Centre Scientifique et Technique du Batiment" numerous calculations with third order matrix (for electric lighting) and fifth order matrix (for daylighting).

In order to obtain equation (5) of O'Brien and Howard from my equation (2), we must use the formula

$$\sum_j q_{ij} A_j = A_i \dots \qquad (5)$$

which means that the elements A make, altogether, a closed envelope. Nevertheless, the authors' method and mine are nothing more than an inversion of matrix and, although I have no personal knowledge in the matter, I believe that the electric network is not a very suitable apparatus for this computation. Since the authors' method is by no means a complicated one, I assume that the reason must be found in equation (5) above. Is my explanation correct?

Note that R. Cadiergues in France is building a "Comfortron" using an electric network. This apparatus involves all the elements of comfort (not just visual) and will solve our interreflection problem as well.

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PHELPS MEAKER:* The authors have mentioned the fact that quite a large number of people are working on solutions of this problem as a whole. It has been observed that each of them is likely to have need for somewhat different flux transfer concept or ratio. There is a pressing need for action by the IES Nomenclature Committee, as well as by the CIE, to review the entire situation and devise suitable terms. In the United States we tend to adopt short-cut terms and give them a special meaning. It has been noticed in the French writings, for example, that it has been necessary sometimes to use very unwieldy expressions in the absence of well-defined descriptive names.

The term "shape modulus" seems to convey more than

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the simple flux transfer relationship. As used, it does not relate to the shape of an enclosure, but more to the orientation of two surfaces relative to each other. Even here, the form of one surface can be specific only with respect to a single point on the other. This is one quantity which needs to be replaced by a better term.

Since much of the handwork involves the determination of the "shape modulus," it is reassuring to learn that extensive tabulations have already been made in the field of radiant power transfer, etc. It seems in order to ask whether these tables are adequate to cover practically all lighting conditions. Is it foreseen that we may need to have our own complete set of tables or graphical representations to cover this?

Since Professor Yamauti has contributed substantially to this progress, it is hoped that he will submit a discussion of this paper. Professor Yamauti was in this country just a year ago, and said that he was still interested in this branch of mathematics.

R. O. PHILLIPS:* This paper is an interesting contribution to the growing literature on what the authors refer to as the "finite difference equation" method for the solution of interreflection problems.

The fundamental equation of flux transfer (Equation 2) can be solved rigorously for certain simple shapes such as the sphere. In most other cases, some approximation must be introduced, either: (a) the use of an approximate expression (commonly an exponential kernel) for the basic flux distribution, or (b) the use of finite elements instead of infinitesimals, but with true values (shape moduli) for the flux distribution.

It is evident that the accuracy of the finite difference method depends on the number of surface elements into which the space is supposed to be divided, the larger the number, the smaller the "truncation error," but the greater the labor involved in computation. The interesting point then arises as to whether a finite difference method employing a limited number of surface elements but with true values for the "shape moduli" is more accurate, or less, than an integral equation method using an approximation for these values. This paper shows, in Table I, that for one particular case, the finite difference method, with as few as six surface elements, gives results which differ from the exact values by no more than 1.9 per cent, while the alternative method, involving an exponential kernel, gives differences some ten times as great.

The writer has made a number of somewhat similar comparisons of which the following is an example: Cubic room ($k_r = 1$), surface reflectances 0.8, 0.5 and 0.1 for ceiling, walls and floor, respectively; all direct flux to the ceiling. The ceiling and floor are each taken as a single surface, the walls divided into three horizontal strips comprising the central half and the upper and lower quarters. Values have been calculated by the finite difference method with the use of the following:

(a) Exponential approximations for the shape moduli;

(b) True values;

and with unit flux on unit area of the ceiling. Results are given in Table A with percentage differences from the published integral equation values.

Again it is found that the differences between infinitesimal and finite methods are negligible when the same values of shape moduli are used, even for as few as five surface elements, but considerable when true values are used for the latter method. Available evidence (to be published) suggests that the latter values are more correct and therefore that the finite difference method provides a powerful tool for interreflection analysis.

Even for a limited number of surface elements, the computations by this method can be quite laborious, but they are considerably aided by the use of modern computers, either digital or analogue. The authors are to be congratulated on the development of a comparatively simple and flexible computing tool. A particular merit in this appears to be the ease with which the effect of changes in flux inputs can be studied to build up a desired luminance pattern.

BILL F. JONES:* I should first like to compliment the authors on their clear statements of the synthesis procedure, which is too often lost sight of in our design procedures. This formulation, and the fact that the half of it represented by the physical system is currently soluble by computer, leads us to the interesting thought that if the psychophysical system can even be analogized, the entire problem of lighting design can be programmed on a computer and a solution obtained for any particular situation, with the inputs being modified by the error feedback to tell us what inputs we need to satisfy the design criteria.

Next, I should like to note that we have here a simple explanation of the finite difference equations and their application to computers which should go far in clearing up the existing confusion.

I feel particularly fortunate that the authors chose to investigate, with the digital computer, the same problem of Dr. Spencer's that Roy Jones and I have investigated by analogue means. The results confirm the accuracy of the analogue computer from an absolute standpoint.

It would indeed be desirable for a number of people to begin making use of these techniques to investigate the various problems of lighting which have been plaguing the industry for years.

PHILIP F. O'BRIEN AND JAMES A. HOWARD:** The authors wish to thank the discussers for their helpful and stimulating comments.

Professor Spencer's comments include a quotation from our paper which, when taken out of context, implies that all

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TABLE A (Phillips' Discussion).

Surface	Interflectance Method	FINITE DIFFERENCE METHOD			
		Exponential Values (a)	Per Cent Difference	True Values (b)	Per Cent Difference
Ceiling (L_c)	0.924	0.919	−0.5	0.906	− 1.9
Floor (L_g)	0.0222	0.0225	+1.4	0.0268	+20.7
Upper walls (L_1)	0.227	0.225	−0.9	0.212	− 6.6
Central walls (L_2)	0.134	0.133	−0.7	0.124	− 7.5
Lower walls (L_3)	0.0751	0.0749	−0.3	0.0718	− 4.4
Work-plane (E_{wp})	0.318	0.322	+1.3	0.357	+12.2

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numerical methods for lighting calculation are new. The complete sentence reads: "Although the finite difference equations were suggested by Yamauti in 1926, this numerical method for the solution of the Fredholm integral has been developed in the lighting literature only recently." As stated clearly in this sentence from the paper, a numerical method of a particular kind was reported in the context of lighting calculation as early as 1926. The work of Moore and Manning and White, as referenced by Professor Spencer, did not employ the finite difference approximation of the Fredholm expression of the second kind, but rather used the technique of summation of infinite series of multiple reflections from finite or discretized areas which defined the space. Operations with the matrix which represents the finite difference approximation are altogether different from the techniques employed by Moore, *et al.*

The authors do not suggest, as indicated by Professor Spencer, that the synthesis of lighting systems is a new concept. We simply state that the idea of synthesis has been neglected to a great extent in the recent lighting literature. In addition, it is suggested that the use of the finite difference approximation allows the employment of the modern analogue and digital computers as aids in the synthesis of lighting systems.

The contributions of Professors Moon and Spencer to the analysis and synthesis of lighting systems are effectively presented in their excellent book, *Lighting Design*.[1]

In reply to Mr. Dourgnon's comment regarding the "truncation error," this is a universal problem of numerical analysis and is described in detail in most books on numerical analysis, for example, Kopal's *Numerical Analysis*.[2]

With regard to the shape modulus $F_{i\to j}$, this is the fraction of diffuse flux emitted by finite area i that is directly incident on finite area j. It is clear then that $F_{i\to j} \equiv q_{ij}$. As made clear above, the flux is in the direction of the arrow in the symbol $F_{i\to j}$. The authors would prefer not to use the symbol q for the shape modulus because q_{ij} is used in the United States to mean "net flux exchange between surfaces i and j. The symbol F is used extensively in the United States literature to mean "shape modulus," as, for example, in Jakob's *Heat Transfer — Volume II*.[3]

Mr. Dourgnon is correct in his careful differentiation between the shape modulus $F_{di\to j}$ (differential area to finite area) and the shape modulus $F_{i\to j}$ (finite area to finite area). The finite area to finite area shape modulus ($F_{i\to j}$) was employed exclusively for the computations reported in Table I of the paper.

We prefer to use the concept of the flux sent per unit area or luminous emittance, rather than the flux received per unit area, as employed by Mr. Dourgnon, for the following reasons:

(1) The concept is more adaptable to analogue computer use because the output of the computer consists in electrical potentials representing emittances in the room.

(2) The magnitude of the *average* luminous emittance of every surface in a room allows the computation of the illumination at any differential real or imaginary surface element within the enclosure by the relationship

$$E_{di} = \sum_{j=1}^{j=m} F_{di\to j} L_j$$

where:

E_{di} = illumination of a differential surface element di at any location within the enclosure.

$F_{di\to j}$ = fraction of flux streaming from differential area di which is incident on finite area j.

L_j = the average luminous emittance of finite areas j which can be viewed directly from the differential area di.

(3) The concept of a self-luminous source (*i.e.*, regarding the initial direct flux which is reflected from a surface as causing the surface to be self-luminous) is particularly useful when luminous ceilings and other architectural or "built-in" lighting is employed.

As suggested by Mr. Dourgnon, the fundamental operation of lighting analysis (*i.e.*, the computation of the total luminous emittance vector $L_1, L_2 \ldots L_n$) is the inversion of the transfer matrix which describes the room shape and reflectance distributions. It is interesting that the highly restricted problem of reverse analysis (*i.e.*, the computation of the stimulus vector $L_{01}, L_{02} \ldots L_{0n}$) as suggested by Waldram, does not require the matrix inversion operation. When large tabulations of inverted luminous transfer matrices are required, the large-scale high-speed digital computer is clearly superior to the analogue computer. However, low cost and ease of operation are factors which favor the luminous analogue computer for exploratory studies and for lighting synthesis. (NOTE: Lighting synthesis is defined as the selection from multiple correct solutions of the *optimum* room shape, reflectance distribution and excitation vector.)

With regard to the shape modulus, Mr. Meaker states that ". . . the form of one surface can be specific only with respect to a single point on the other." In the actual case, the form of one surface with respect to another is specific not only to a single point (differential surface element) but also to the entire second finite area. Both the differential area to finite area ($F_{di\to j}$) and the finite area to finite area ($F_{i\to j}$) shape moduli may be used depending upon the application.

The tables and graphical representations of shape moduli which are now available in the literature are adequate for most lighting calculations. However, if the finite difference equations for lighting calculations come into widespread use, some central agency should prepare an integrated publication of shape moduli for use by lighting designers.

Mr. Phillips has brought to the attention of illuminating engineers in the United States the comparison of luminous quantities as obtained by two techniques for the solution of the fundamental equation of flux transfer. It is clear that the errors arising from the use of an exponential approximation for the shape modulus, as in the interflectance method, can be avoided. Mr. Phillips is in perfect agreement with the authors when he states: "A particular merit in this (luminous analogue computer) appears to be the ease with which the effect of changes in flux inputs can be studied to build up a desired luminance pattern."

The kind comments of Mr. Jones are appreciated by the authors. Mr. Jones not only supports the use of the finite difference approximation, but also uses this technique in his work as a lighting engineer. To our knowledge, Mr. Jones is the only engineer outside the University of California who is now using a luminous analogue computer.

The authors wish to draw attention to the international character of the discussion of this paper. Mr. Dourgnon of France and Mr. Phillips of Australia have contributed significantly to understanding of the problems considered in this paper even though they were unable to attend the actual presentation of the paper. International cooperation of this character will certainly accelerate the development of lighting technology.

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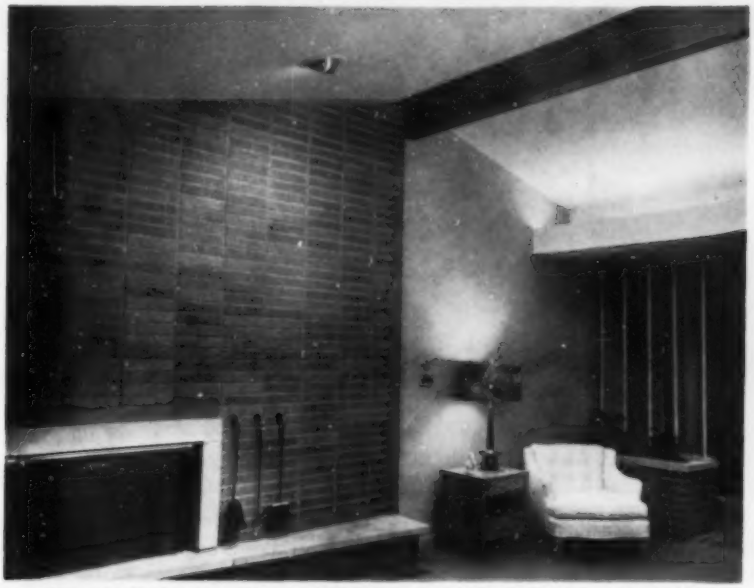


INSTALLATION IN THE RESIDENCE OF WILLIAM P. FINNERAN, COLUMBUS, OHIO.

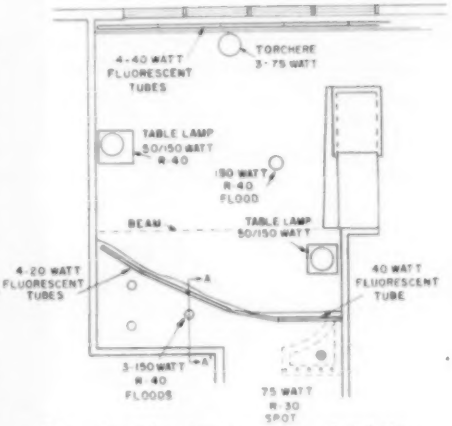
Lighting a Formal Living Room

LIGHTING OBJECTIVE: To provide decorative lighting and a comfortable level of general illumination in a living room reserved for formal entertaining.

GENERAL INFORMATION: Shown below is a plan view of this formal living room in the home of a builder. (This house has a large family room used for all other family activities.) Ceiling height is 8 feet at the window end, slopes to 11½ feet at the line of the transecting beam and is 9½ feet at the back of the cove. The ceiling is white (80% RF), sidewalls are turquoise (55% RF), fireplace terra cotta brick (25% RF), carpet turquoise (35% RF), over draperies light turquoise (60% RF), and under draperies off-white (75% RF).

INSTALLATION: General lighting is furnished by a dimmer-controlled lighted cornice (see elevation) extending across the window wall at one end of the living room and continuing across the dining room adjacent to it, and by a lighted cove (see elevation) at the other end of the room. This cove is formed by a natural extension of the hallway ceiling out under the higher sloped ceiling of the living room. Deluxe cool white fluorescent tubes are used over the turquoise and white draperies and deluxe warm white (Homeline) in the cove.

The planter under one end of the cove is accented by a recessed luminaire (Spear Lighting Manufacturing Co., Brooklyn, N. Y., No. 206 with 2-inch opening) equipped with a 75-watt R-30 spot lamp. Over each of the chairs and over the coffee



Plan view showing locations of lighting equipment.

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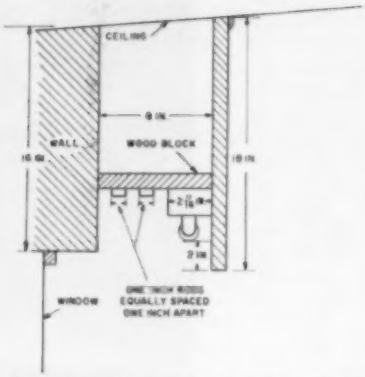

Cross section detail of cove lighting.

table at the other side of the cove are three recessed units (Spear No. 210), each with a 150-watt R-40 flood lamp. The fireplace wall is lighted by a recessed adjustable ball (Spear No. 221) with a 150-watt R-40 flood lamp. The hall luminaire is a Lightolier No. 7946 with a 150-watt lamp. Portable lighting in the room consists of two table lamps (one beside the white chair with an 8-inch glass diffusing bowl and a 50/100/150 watt lamp, and one at the end of the davenport with a wide harp to accommodate a 50/100/150 watt R-40 lamp) and a torchere with a three-way switch and three 75-watt lamps.

The average illumination in the room, thirty inches above the floor, is 15 footcandles with all the lighting on at maximum brightness. At reading positions by the two table lamps, the levels are 45 and 30 footcandles, and the spots recessed in the cove each produce 25 footcandles at furniture level.

Builder: W. P. Finneran, Columbus, Ohio; lighting designed by Helen W. Marriott, Home Lighting Advisor, Columbus and Southern Ohio Electric Co., Columbus, Ohio.

Lighting data submitted by Helen W. Marriott as an illustration of good lighting practice and to aid in the design of similar installations.

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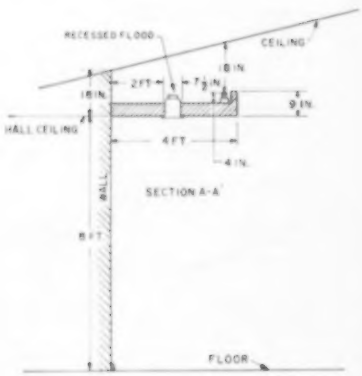

Cornice detail.

Light Directing vs. Diffusing Media In Luminous Ceiling Areas

By H. A. ODLE
R. L. SMITH

THE ADVENT of the fluorescent lamp, emitting over twice as much light as the filament lamp, has hastened the trend toward higher levels of illumination. While in pre-fluorescent days a lighting level of 50 footcandles was considered the practical limit, illumination levels of 100 footcandles are now commonplace for stores, offices, drafting rooms, etc., and lighting installations producing 150, 200 footcandles and higher are beginning to show up more and more frequently.

This trend for higher lighting levels has brought with it a two-fold challenge. In the first place, it has been found necessary and advisable to increase the area of the light producing elements so that they now often cover a large percentage of the ceiling or even the entire ceiling. It is obvious that, to make such lighting arrangements practical, plastics materials were promptly given consideration. For a number of reasons, mostly because of their light weight, plastics are now well established in various forms as one of the most suitable means of providing large luminous area installations.

A second development was likewise logical. As it became desirable to increase the illumination level at the work plane, it became apparent that to provide a visually comfortable atmosphere at these higher levels it would be necessary to control the brightness of the luminous areas at high angles toward the occupants of the room.

An early approach to this problem was the use of diffusing material extended to cover larger areas in order to reduce the surface brightness. The first installations of this nature produced levels of from 20 to 50 footcandles. The limit to such a system of a diffusing medium is reached, however, when the entire ceiling is covered. More illumination, then, means more high angle brightness and more discomfort to the occupants of the room.

One method of achieving the goal of both high illumination levels and maximum visual comfort is for the lighting medium to control rather than diffuse the light. One medium providing this needed control is the prismatic lens plate made of a transparent material (glass or plastic) on whose surfaces have been molded prisms designed to refract or bend light which would ordinarily go at high angles into lower, more nearly innocuous, zones.

Fig. 1 shows a simplified ray trace of a prismatic panel. Ray 1 represents near grazing light striking the top surface and bent down internally to ray 2. Most of the light represented by ray 2 strikes surface "B" of the prism and emerges as ray 3 at a maximum angle of 60 degrees. Since the projected area of side "A" is small in the direction of ray 2, it intercepts only a small portion of ray 2 and reflects it back up into the fixture as shown by ray 4. Most of ray 4 is again reflected back down by the fixture and emerges at lower angles. Light that strikes the panel at angles nearer the normal as represented by ray 1′, is refracted through as shown by rays 2′, 3′, and 4′. Fig. 1, then, shows that it is possible to design a prismatic structure that will accept light through a full 180 degrees on its top surface and substantially confine this light to 60 degrees from nadir as it emerges, thus greatly reducing the glare zone light from 60 degrees to 90 degrees.

From the standpoint of quality of illumination, this control of direct glare toward the eyes of the observer is one of the most important functions of the control material. Fig. 2 shows the candlepower

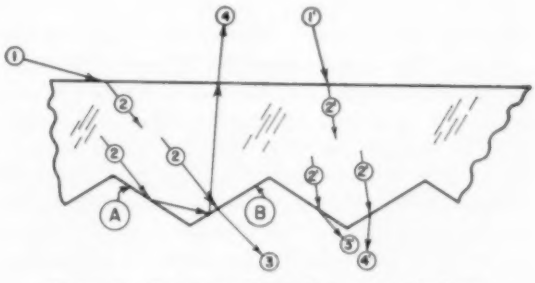

Figure 1. Ray traces through a prismatic lens.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.
AUTHORS: Holophane Company, Newark, Ohio.

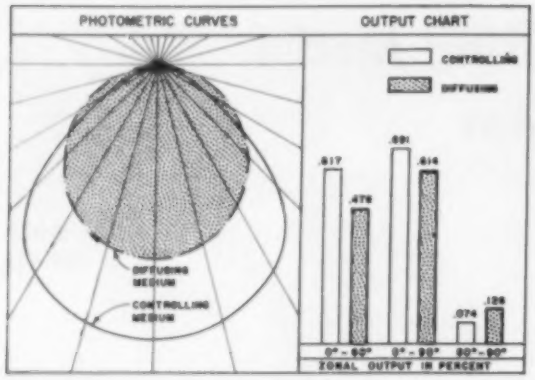

Figure 2. Candlepower distributions and output values by zones for luminaire with two different enclosing media.

distribution comparison between a controlling medium (prismatic clear acrylic panel with base thickness of ⅛ inch) and a diffusing medium (translucent vinyl panel with thickness of .006 to .008 inch) typical of those in use at the present time. Since the polar candlepower plot gives a very distorted picture of actual output, the bar graph at the right is shown to give a true picture of output values in the various zones. Fig. 2 shows that, in the 60-to-90-degree zone, the diffuse enclosure has an output of 22 per cent of its total, as compared with only 10½ per cent for the control medium. This does not mean that the relative comfort of the two types is in the ratio of 22 to 10½. Rather, comfort studies indicate that the discomfort effect of direct glare is proportional to the square of the brightness toward the observer in the glare zone. This means that actually a ratio of 4.4 to 1 would apply in evaluating the relative glare effects of the two enclosing media.

An analysis of the design of prismatic structures indicates that in a lighting installation the prismatic panels should give more light on the work plane than diffuse panels. This is primarily due to two factors. First, the material from which prismatic panels are made is crystal clear and therefore should have a higher total output than the diffusers, the magnitude of the difference being a function of the density of the particular diffuser chosen. The second reason for expecting a higher utilization of light from the control medium is that since the prismatic enclosure contains the light within angular limits of approximately 0 to 60 degrees, it is reasonable to expect that less light will strike the room walls and more will strike the work plane directly. In a large room, of course, this second point would not result in an appreciable increase in utilization but as the room ratio becomes smaller the increase in utilization should become more and more pronounced.

Fig. 2 shows that the prismatic total output is about 12½ per cent higher than the total output of the typical diffuser chosen. It can therefore be concluded that in an infinitely large room, neglecting ceiling reflected component, the coefficient of utilization can be expected to be 12½ per cent higher for the prismatic panels than for the diffusing panels tested.

Test Installation

To determine how much this 12½ per cent difference in coefficient of utilization between control panels and the diffuse panels tested increased as the room ratio became smaller, we set up a test room that could be varied between room ratios of 0.8 to 1.45. The plenum depth was 8 inches and the reflection factor was 0.85. Rapid-start lamps in continuous rows spaced on 12-inch centers were used. The room was air-conditioned to 25C. No attempt was made to air-condition the cavity, or to prorate the results in terms of an air-conditioned cavity, since we felt that to do so would present unrealistic results. Temperature readings were taken in the cavity, however, and they ranged between 40 and 43C.

If the test results were prorated to the normal temperature rating of fluorescent lamps,[1] all coefficients could be expected to be from 10 to 12 per cent higher than those shown. Fig. 3 shows a partial view of the test room and Fig. 4 shows the results of actual measurements in the test room, indicating that for small rooms the coefficients of utilization for controlling media are in the order of

Figure 3. Photograph of test installation.

25 per cent higher than those for diffusing media, bracketing the difference at about 12½ per cent for very large rooms to about 25 per cent for small rooms.

Another question involved in this investigation was that of predicting coefficients of utilization for room ratios other than those tested. Previous methods of measuring or calculating the output of luminous ceilings or ceiling panels have assumed cosine or near cosine transmission and reflection characteristics for the transmitting medium as would be the case with diffusing panels. Actually, light controlling prismatic panels have transmission and reflection characteristics that vary considerably from a cosine distribution, so that it was necessary to find a way of predicting coefficients from actual photometric candlepower test data. A logical step seemed to be to test a large fixture constructed with the same type and depth of cavity and the same lamp spacing as the actual plenum, and then extend this distribution curve to coefficients for all room ratios by means of the zonal interflectance method.

In order to use the zonal interflectance method, however, it is necessary to specify a ceiling reflection factor. The first step, then, in this phase of the investigation was to examine the reflecting characteristics of the prismatic panels from the room side. As was previously noted, the reflection factor of a

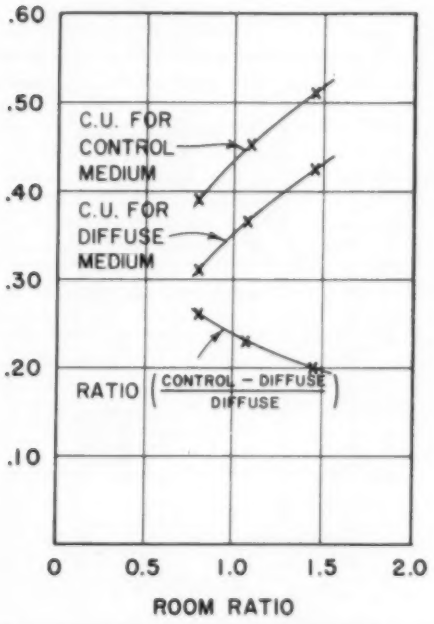

Figure 4. Measured coefficients of utilization and difference ratio for luminous ceiling installation with two types of enclosing media.

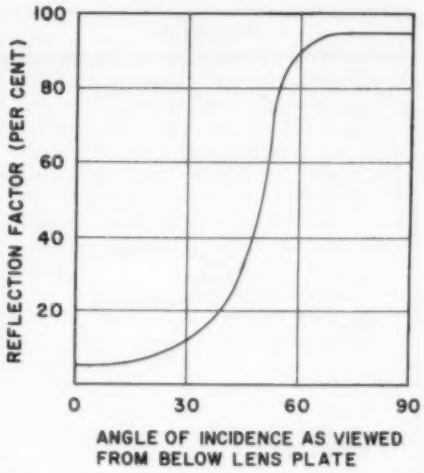

Figure 5. Theoretical reflection factor curve for prismatic lens plate described.

perfect diffusing material is constant regardless of the angle of incidence of the impinging light. The reflectance of practical diffusing media used for luminous areas varies only a relatively small amount from the perfect diffuser but, on the other hand, control equipment such as prismatic lenses vary considerably as a function of the angle of incidence of the impinging light, as shown in Fig. 5. This curve is based on angles of incidence as seen from the room side of the lens. The light reflected from the floor, then, would strike the panel at angles in the vicinity of 0 to 45 degrees, while the light reflected from the walls would probably strike the panels at angles of from 45 to 90 degrees. Thus, the same prismatic lens would have different reflection factors in each different installation, depending on the proportions of light striking the lens at various angles of incidence. It was not satisfactory to measure the reflection factor of the prismatic panels with a reflectance meter.

From Fig. 5 it may be seen that if light impinges on the lens approximately equally at all angles of incidence, as might be the case in an average room, the equivalent reflection factor is about 50 per cent. Calculations can be made for amounts of light striking the lens at various angles of incidence for each particular installation, but the complications introduced by considering the cavity as a part of the ceiling reflecting system make these calculations extremely difficult.

In an attempt to verify the equivalent reflection factor assumed from Fig. 5 for an average room, a test set-up was devised. It was noted that Russell and Churchill[2] had measured the reflectance value of diffusing media by placing black velvet behind the material before taking the meter reading. It

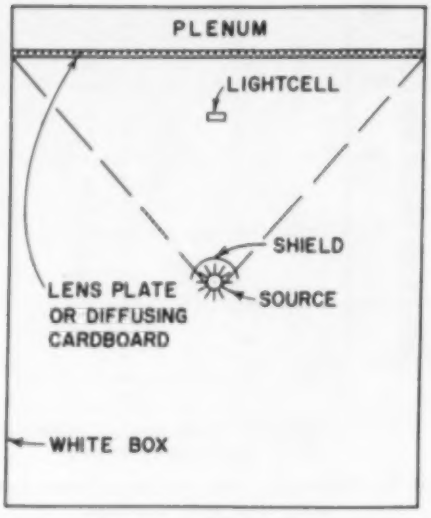

Figure 6. Test device used to determine equivalent reflection factor for prismatic panels in luminous ceiling installation.

was felt that a true reflection factor for prismatic panels could be obtained only by assuming that the reflecting medium is not the enclosing medium alone, but the enclosing medium together with the cavity above it. For the test set-up a relatively small box was used, to simulate a room with its plenum; with all dimensions scaled down as shown in Fig. 6. Light was introduced to light the room but was carefully shielded so that no direct light could fall on the ceiling. Lenses were inserted to cover the plenum and a reading taken with a lightcell, the lightcell acting as a wide-angle brightness meter. Then the lenses were taken out and various pieces of cardboard having different diffuse reflection factors were inserted, until the meter reading was again the same as with the lenses. The diffuse reflection factor of the cardboard was then assumed to be the equivalent reflection factor of the lens-plenum combination, and was found to vary from 45 to 60 per cent depending on the room and the cavity proportions, the room and the cavity reflection factors, etc.

Since ceiling reflectance variations make a relatively small difference in the over-all utilization of light in a room, it was assumed for all future calculations that the equivalent reflection factor of a lens plate was 50 per cent. Since a portion of this 50 per cent is light that has re-entered the cavity and returned again, it is not to be construed that the transmission factor of the lens must be less than 50 per cent. Under those conditions found in an ordinary luminous area installation, the lens-cavity reflection factor plus the transmission factor can and do add up to considerably more than 100 per cent.

Having a ceiling reflection factor to use in the zonal interflectance method, the next step was to test a section of ceiling. The section tested was four feet square. This seemed to be a logical choice since the spacing-to-mounting-height ratio generally used in the zonal interflectance method to calculate coefficients for fluorescent units is 0.4, and such a fixture extended for zonal interflectance computations in a room with a ceiling height of 12½ feet would just cover the entire ceiling.

Fig. 7 shows the coefficients for luminous ceilings with the two different enclosing media and also shows the measurements taken in the test room. Within the range of room ratios in which measurements were made, the conformity of results was thought to be good—sufficiently good to justify the assumption that for all room ratios it is possible to consider a luminous ceiling to be made up of a number of large luminaires. A photometric test on one of these typical sections of ceiling can then be used with the zonal interflectance method to obtain coefficients of utilization for the entire luminous ceiling.

Conclusions

The paper compares characteristics of two types of media commonly used for luminous areas—light controlling and diffusing—and presents reasons for

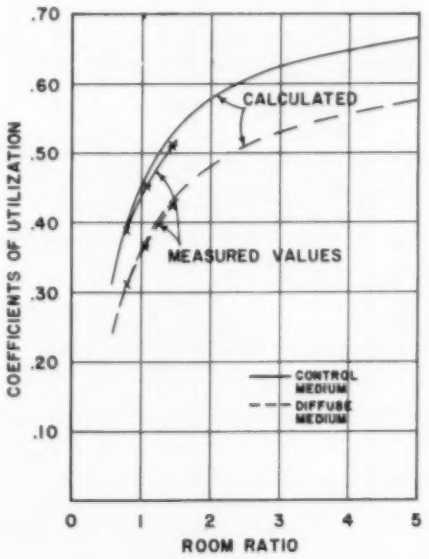

Figure 7. Measured and calculated coefficients of utilization for luminous ceiling installation with two enclosing media. (Ceiling, 50 per cent; walls, 50 per cent; floor, 10 per cent.

expecting better utilization of light from a scientifically designed controlling medium.

In very large rooms, the light controlling medium shows an increase in coefficients of utilization of about 12 per cent over the diffusing medium and for small rooms this increase goes up to about 25 per cent.

The paper also shows that it is possible to consider a luminous ceiling made up of a number of large luminaires. A standard photometric candlepower test on one of these typical sections of the particular ceiling involved can be used with the zonal interflectance method to obtain coefficients of utilization for the entire luminous ceiling.

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2. Moon, Parry, and Spencer, Domina Eberle: "Interflections in Coupled Enclosures," *Journal of the Franklin Institute*, Vol. 250, p. 151 (August 1950).

3. Jeavons, R. T., Horner, R. H., Burnham, R. D.: "Cavity Efficiency for Translucent Ceilings," ILLUMINATING ENGINEERING, Vol. L, No. 3, p. 137 (March 1955).

4. Committee on Lighting Design Practice: "Calculating Coefficients of Utilization," ILLUMINATING ENGINEERING, Vol. LI, No. 5, p. 385 (May 1956).

DISCUSSION

J. N. ROBERTSON:* Messrs. Odle and Smith have given us a very fine application paper. The data presented appear to be sound, but I cannot agree with all of their conclusions.

The ability of the prismatic panel to reduce direct glare and to give better illumination on horizontal surfaces represents another step forward. I should like to point out, however, that there are a few applications with specular tasks and tasks not in a horizontal plane where a cosine distribution will provide a better total luminous environment.

I believe that the authors have established that it is feasible to consider a luminous ceiling as being made up of a number of large luminaires. This simplifies obtaining coefficients of utilization by the zonal interflectance method and while it is not rigorously correct, it should be sufficiently accurate for practical design use.

The authors' conclusion, with which I cannot agree, is the following: "The paper compares characteristics of two types of media commonly used for luminous areas — light controlling and diffusing . . ." I cannot interpret that they have compared two *general* types. Rather, it appears that they have compared one specific prismatic panel with one specific diffusing medium and have stated the results as a general conclusion. The prismatic panel tested may be fairly typical of prismatic lenses, but I doubt that there is a typical diffusing medium. There are many diffusing media in common use. Some, which have good hiding power, are efficient light transmitters, and others are very poor.

In my own experience, I have found that some translucent vinyl, such as that tested by the authors, provides relatively low coefficients of utilization as compared to some of the other diffusing materials.

Rather than draw general conclusions based on one set of tests, I should like to see the authors make a broader contribution to general lighting practice. I should like to see them continue their test work and provide comparative information on many translucent materials now commercially available.

*Department of Water and Power, City of Los Angeles, Calif.

G. W. CLARK:* In essence, the authors of this paper appear to have shown that some of the relative lighting characteristics of prismatic and diffusing shielding media can probably hold for wall to wall ceiling systems as well as for conventional luminaires. As with troffers, for example, those employing prismatic shielding media tend to have higher efficiency and narrower distribution which combine to give higher coefficients of utilization, especially in smaller rooms.

From a brightness control standpoint, as the authors point out, the brightness of the prismatic media is usually lower in the direct glare zone. Likewise, it is generally higher in the reflected glare zone.

In connection with the brightness evaluation, the authors suggest a discomfort ratio of 4.4:1. Based on papers by Fry[1] and Hopkinson and Bradley,[2] it would seem that we are not really in a position to apply such a factor, particularly to luminous ceilings.

Our experience with luminous ceilings using diffusing and louvered shielding media has made it evident that the assumption of "average" cavity conditions for surface reflectances and proportions is not satisfactory. We are inclined to believe, therefore, that similar assumptions for prismatic media are to be questioned. The influence of both these conditions over the wide range of variation common in actual practice is substantial.

The idea of using standard photometric tests for luminous ceilings has long intrigued all of us who have particular concern with this type of lighting system. Unfortunately, this does not take into consideration the coupled enclosure effect which Moon and Spencer have explained. As a matter of fact, this effect should probably be considered for applications where large area troffers cover a major part of the ceiling. Perhaps if a series of tests were made with a variety of simulated cavity conditions these data could be used to develop coefficients which do take into consideration the "coupling" effect.

1. Fry, Glenn A.: "The Evaluation of Discomfort Glare," ILLUMINATING ENGINEERING, Vol. LI No. 11, pp. 722-728 (November 1956).
2. Hopkinson, R. G., and Bradley, R. C.: "A Study of Glare from Very Large Sources," a paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.

D. E. SPENCER:** The possibility of employing media which are not perfectly diffusing in luminous ceilings merits considerable study. For some applications it may be desirable for the brightness of the ceiling as we look down the room to be less than the brightness seen when we look straight up. However, as luminous ceilings already employ very low brightness ratios when used with suitable reflectances, the improvements obtained with the system of prismatic lenses studied by the authors is slight.

Two advantages are pointed out: about half as much light is emitted in the 60- to 90-degree zone, and the quantity of light may be 12 to 25 per cent greater. The authors suggest that the "discomfort" is thus reduced by a factor of 4. They should remember that the foundations of all proposed methods of evaluating discomfort are extremely shaky at the large areas encountered with luminous ceilings. The same methods predict that the pleasant outdoor environments studied so carefully by Logan are "intolerable."

The gain in quantity of light obtained by a 12 to 25

*Sylvania Electric Products, Inc., Wheeling, W. Va.
**University of Connecticut, Storrs, Conn.

per cent increase is of negligible significance in improving visual performance, since with luminous ceilings we are operating with generous quantities of light in a nearly horizontal region of the response curve.

The authors mentioned only the *advantages* of prismatic lenses over diffusing media. They neglected to mention the great disadvantage of their "crystal clear" media which, in my opinion, far outweighs its advantages. As far as reflected glare is concerned, the system suggested in this paper is similar to a louverall ceiling or to a set of bare lamps placed on the ceiling. For anyone who works with pen, pencil or printed matter, the reflected glare would be very unpleasant. This system looks like a luminous ceiling if one stands outside the room looking in. It is fairly satisfactory if one keeps a horizontal line of sight and ventures into the room. But, if one looks up or tries to work in such a room, he will find that the luminous environment is no better than that provided by bare fluorescent lamps. The reflected glare produced by bare fluorescent lamps is definitely perceptible at the levels of lighting employed today.

The difficulty is that the authors have not measured the most significant photometric quantity. They have attempted to characterize their prismatic ceiling by a candlepower distribution (thus employing a cone of light which diverges from a point on the ceiling). This measurement gives no indication of how the ceiling will appear when one looks up at it or when one looks down and encounters reflected glare. What they should have measured is the brightness as viewed by the observer. Such measurements would show that the brightness of this ceiling is very non-uniform for angles close to vertical. One sees a striped pattern of bare lamps and white ceiling, and the brightness of the slightly distorted lamp images is nearly as great as that of a bare lamp. Measurement of candlepower loses the effect of these large variations and leaves only averages which are of no visual significance.

A system in which the brightness of a luminous ceiling varies with angle while reflected glare remains imperceptible was first used commercially in the Fitchburg Youth Library in 1950. Here, Robert Newman and I combined acoustic fins with diffusing luminous ceiling panels in such a way that both acoustic and visual criteria were satisfied. This should not be the sole method of reducing the brightness of the ceiling as we look down the room. Other methods should be developed, but if they are to contribute to the progress of luminous ceiling design, they must be carried out in such a way that both angular control of brightness and elimination of perceptible reflected lamp images are obtained. The authors have obtained a modicum of angular control at the expense of introduction of the maximum possible reflected glare.

May I repeat a suggestion I made in a discussion of a paper by Harrison in 1944, "It is time to take into account reflected glare."

H. A. Odle and R. L. Smith:* We recognize Mr. Robertson's point that coefficients of utilization obtained with diffusing materials vary some with the density of the material. Russell and Churchill's paper, "Measured Utilization Data for Luminous Ceilings,"[1] gives the expected spread between diffusing media of different densities. Corrugated vinyl, however, seems to be the diffusing material most often used for entire luminous ceilings.

Mr. Clark brings up a very good point that the ratio of differences of coefficients of utilization for diffusers *vs* prismatic material may change with varying cavity proportions and surface reflectances. Unfortunately, time did not permit investigation of this aspect of the problem.

Mr. Clark also mentions the consideration of the "coupled enclosure effect" as being a deterrent to the use of standard photometric tests for predicting results from luminous ceilings. This effect influences the output of the cavity-source as a function of the room reflectances. The effect, however, is quite small. Also, since the Moon-Spencer equations assume that the enclosing medium is perfectly diffusing, we felt that they would not apply to an analysis of a light controlling medium. Within the scope of our investigation in which we could check measured values against calculated values, we could not find evidence to support the contention that the coupled enclosure effect is a significant quantity.

Dr. Spencer points out that from a reflected glare stand point the prismatic lens will be less favorable than a diffusing medium. It is true that as a system puts out more light its brightness at some angles must increase. We would like to point out, however, that even when one is looking straight up at the prismatic lens, the brightness is always less than half the brightness of a bare lamp and decreases rapidly at higher angles of view.

1. Russell, A. H., and Churchill, R. D.: "Measured Utilization Data for Luminous Ceilings," Illuminating Engineering, Vol. LI, No. 4, pp. 309-319 (April 1956).

*Authors.

Do you know that . . .

the Cornhusker Section is composed of all of Nebraska plus a part of Iowa, that El Paso, Texas is in the New Mexico Section? These and other interesting facts are revealed in the map of IES Sections and Chapters on page 23A. Here is a handy guide to the geographical organization of the Society.

INSTALLATION IN OMAHA, NEBR.

Decorative Lighting for a Penthouse Living Room

LIGHTING OBJECTIVE: To provide decorative illumination in a contemporary interior to dramatize aquariums, sculpture and plants.

GENERAL INFORMATION: The living room of this bachelor's penthouse apartment measures approximately 16 feet by 19 feet and the ceiling height is about 10 feet between concrete beams. Along one end of the room is a shelf with aquariums for tropical fish; the opposite end has a bar. Room finishes are as follows:

Ceiling			Carpet	Coral	35% RF
Edges	Gray	30% RF	Draperies	Red, Orange, Lavender and White	35% RF
Lighting Panel	Philippine Mahogany	15% RF	Sofa, Chairs	Yellow and Red	
Walls	Gray	50% RF	Coffee Table	Tan Marble	
	Philippine Mahogany	15% RF	Hi-fi Cabinet	Rosewood	

INSTALLATION: General lighting is provided by a dropped ceiling panel (8 feet 9 inches above the floor) in which are recessed 18 Solar No. 163 louvered downlights as shown in Figs. 2 and 3. The lamps are 150-watt R-40 type in red, amber and blue, and each color circuit is separately controlled by an autotransformer type dimmer. With all three circuits adjusted to their maximum intensity, there is warm amber light which is adjustable through the use of the dimmers to endless varieties of pink and blue to suit the owner's mood. With all lamps on at full voltage, the average illumination on the coffee table is 25 footcandles.

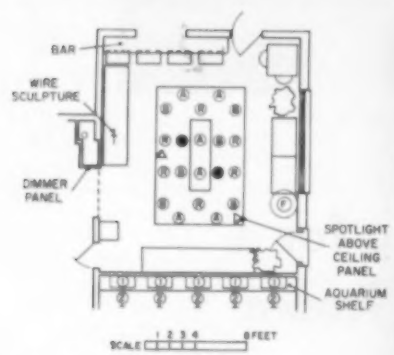
Two Hub No. 8789 theatrical spotlights (with 100-watt G-16½ bayonet base bulbs) are installed on top of the dropped ceiling panel to highlight the plant beside the sofa and the wire

(over)

A.I.A. File No. 31

Figure 2 (left). Close-up of ceiling panel.

Figure 3 (below left). Plan view of living room and aquarium area.
Figure 4 (below right). Close-up showing lighted aquariums and wire sculpture.



KEY TO LIGHTING EQUIPMENT

- Ⓐ SOLAR NO. 163 WITH AMBER 150-W R-40 LAMP
- Ⓑ SOLAR NO. 163 WITH BLUE 150-W R-40 LAMP
- Ⓡ SOLAR NO. 163 WITH RED 150-W R-40 LAMP
- ◁ HUB NO. 8789 THEATRICAL SPOTLIGHT
- Ⓕ LIGHTOLIER NO. 9761 FLOOR LAMP
- ① VIRDEN NO. V-9122
- ② AMPLEX NO. C1154
- ● "MUZAK" LOUDSPEAKER

sculpture on the hi-fi cabinet. Beside the chair by the entrance doorway is a Lightolier No. 9761 floor lamp.

The aquariums open into the room behind. (Actually only the front glass side of each tank, measuring 15½ inches by 25½ inches, is visible in the living room wall.) Over each tank in the adjacent room is one Virden No. V-9122 unit with two 20-watt cool white fluorescent tubes mounted 4½ inches above the water. Also, for added depth and sparkle, one Amplex No. C1154 with a 150-watt R-40 lamp is mounted 12 inches above each tank. The R-40 lamp colors are: straw for the two outer tanks, blue for the center tank and white for the remaining two.

Lighting designed by E. C. Knudson, electrical engineer, and Lee S. Windheim, architectural designer, of the Leo A. Daly Co.; installed by the Miller Electric Co., both of Omaha, Nebr.

Lighting data submitted by E. C. Knudson as one solution to a lighting problem and to aid in the design of similar installations.

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Integrated Ceilings for Illumination

By J. S. HAMEL

Integration is a key word in design and construction today. The modern air conditioned building with ever expanding systems of illumination presents a unique problem of design wherein the elements of illumination must be combined with the ceiling system and air conditioning to reflect a pleasing appearance and an economically justified design. While the physical elements of design must be integrated, for appearance, the economics must also be integrated into the overall cost, to justify the necessary higher lighting levels and better quality of illumination.

Air-conditioning engineers are concerned with the "heat gain" from lighting systems and its relative effect on the cost and operational characteristics of air-conditioning systems. A paper by Sturrock and Schutrum,[1] "A Study of the Extraction of Heat from Fluorescent Luminaires in Air Cooled Rooms," discussed the problems of heat dissipation from luminaires, and it is the intention of this paper to discuss new design and application techniques for the integration of lighting and air-conditioning in order to achieve optimum economics through the use of "Integrated Ceilings for Illumination."

Definitions

The phrase "Integrated Ceiling System," as used in this paper, is defined as a ceiling and lighting system built of non-combustible components wherein certain elements of the ceiling system and lighting system are common to each other, and wherein the fluorescent lamp ballasts are located above the ceiling plane, and are attached to the ceiling suspension grid.

Integrated ceiling systems have been developed for use with various ceiling materials and luminaires ranging from exposed lamps for markets and industrial installations to enclosed surface mounted and recessed luminaires for installations with higher quality illumination.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.
AUTHOR: Consulting Engineer, Burbank, Calif.

The Basic System

Fig. 1 illustrates the elements involving a suspended modular ceiling system. Extruded aluminum structural sections "A" form the basic grid of the ceiling. A raceway "C" of extruded aluminum attached to some of the main runners of the grid serves as a raceway for conductors. These raceways correspond to the spacing of fixture rows. Ballasts "B" are mounted on the raceway "C," and lamp holders in a box "D" are attached to the underside of the grid, in single or multiple to form a continuous or intermittent line of lamps. Wiring from raceway to lamp holders is through connector "E." Branch electric circuits connect to the raceway through junction boxes attached to top of raceway.

Figs. 2 and 3 show a more detailed cross section of several types of raceway in common use and illustrate the relation of the various components.

In the foregoing, Figs. 2 and 3, two basically different approaches are made to the problem of integrating the raceway into the ceiling system. In Fig. 2, the electrical components of the ceiling systems are attached to the ceiling grid after the grid has been installed. In Fig. 3, the raceway is a part of the ceiling grid and is installed by the trade installing the ceiling grid.

These two systems illustrate two different ap-

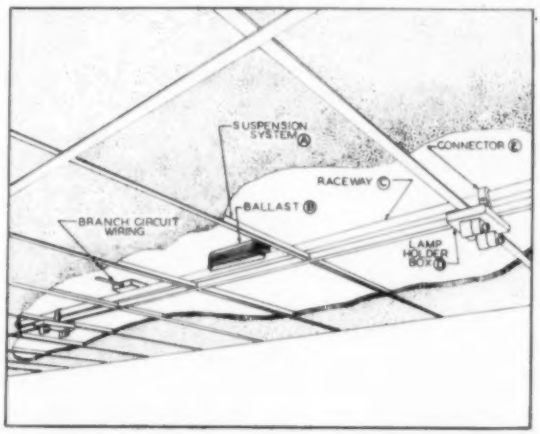

Figure 1. Basic elements of a typical Integrated Ceiling System.

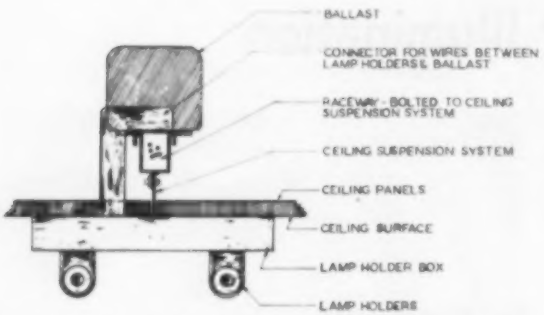

Figure 2. Detail of raceway and luminous elements — raceway attached to ceiling system.

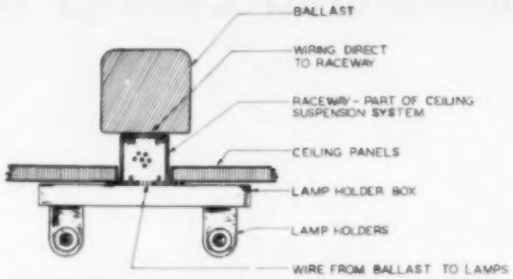

Figure 3. Detail of raceway and luminous elements — raceway is part of ceiling system.

proaches to the integration of the raceway into the ceiling grid system. Each system has distinct advantages. The one illustrated in Fig. 2 separates the electrical components from the ceiling grid so that the work of the electrical trade can be done after the ceiling has been erected. The system illustrated in Fig. 3, while raising a question of trade jurisdictional conflict permits more extensive shop fabrication in that the ballasts, lamp holders, and wiring may be shop assembled in units, reducing field labor costs.

The general appearance of typical installations of integrated ceiling systems are best illustrated by three interiors shown in Fig. 4.

"A" — Exposed lamp installation in a typical market.

"B" — Plastic enclosed luminaire.

"C" — Semi-recessed luminaire with plastic diffuser.

In addition to the simplicity and economics of the combined ceiling and lighting system, for air conditioned structures, heat dissipation from ballasts becomes an important factor, in consideration of air conditioning.

Analysis of Heat Dissipation

Fig. 5 shows a line diagram to illustrate a typical system of air-conditioning and an integrated ceiling system. The air-conditioner circulates air, after cooling or heating, to the room, where it is diffused into the conditioned area through air diffusers. Room air is returned to the air-conditioner, but because of the need for constant fresh air to be added to the conditioned space, only about 70 per cent of the air supplied is returned. This creates a positive pressure in the conditioned space and it is the usual and good practice to exhaust this air with exhaust or relief fans. Where there is a ceiling cavity, it is used as a relief exhaust plenum and room air enters this plenum through relief grilles in the ceiling, to be exhausted to the exterior.

From published data[2] on fluorescent lamp ballasts, the loss for high power factor type ballasts with two 96-inch slimline lamps operating at 425 ma will vary from 26 to 34 watts per two-lamp ballast, with an average of 30 watts per ballast which is approximately 17 per cent of the input power with lamps rated at 74 watts. For the 1500-ma rapid-start lamps, the ballast loss is approximately 80 watts per two-lamp ballast, also, approximately 17 per cent of the input watts with lamps rated at 200 watts each. It will accordingly be assumed in this discussion that approximately 17 per cent of the power input to a fluorescent lamp is ballast loss and this loss is radiated and convected from the ballast, in the form of heat which must be either removed by exhaust or absorbed by the cooling system.

Since the "heat gain" in air-conditioned spaces, from lighting, is directly proportional to the wattage input to the lighting system, it can be assumed that if the ballasts are removed from the conditioned space and located in a ventilated ceiling plenum, approximately all the "heat gain" from the ballasts can be eliminated from the air-conditioning load. The exhausting of the ceiling plenum is a usual and necessary part of the air-conditioning system to relieve the fresh air added to the recirculation air system with integrated ceiling systems. The ballast heat loss is absorbed by the exhaust room air moving through the ceiling plenum and hence may be eliminated from the air conditioning system heat gain.

Fig. 6 shows the effect of lighting load on air conditioning capacity. Using as an example from this table (an installation of 6 watts per square foot for a large office where 100 footcandles of illumination are provided) it is indicated that approximately 41 per cent of the total air cooling capacity

Figure 4A. Exposed lamp luminaires in typical market.

is required for various lighting loads. If the ballasts were not located in the air-cooled room space as illustrated in Fig. 5, this percentage would be reduced from 41 per cent to approximately 34 per cent since the ballast losses amounting to 17 per cent of the total power input, would be dissipated in the ceiling plenum and not added to the room heat gain.

Economics

Building costs today are generally equated to a cost per square foot of structure. The total cost per square foot is not always the sum of all components of the structure. This is particularly true where some components result in cost reduction of others. The actual cost per square foot for illumination and/or ceiling systems must account for the "net" cost to be a true cost figure. With integrated ceilings, this factor becomes increasingly important because of certain contributing costs and savings which must be accounted for in determining the true cost of illumination.

Using an average air conditioning installation cost of $600 per ton* of refrigeration, if 41 per cent of this were lighting load, the cost of lighting in terms of tons of refrigeration would be $246 per ton. The savings applied to this figure would be 17 per cent of $246 or $41.82 per ton of refrigeration.

*One ton of refrigeration is the equivalent of 12,000 BTU per hour. Costs per ton may range from $600 to $1000.

Figure 4B. Plastic enclosed luminaire.

Figure 4C. Semi-recessed luminaire.

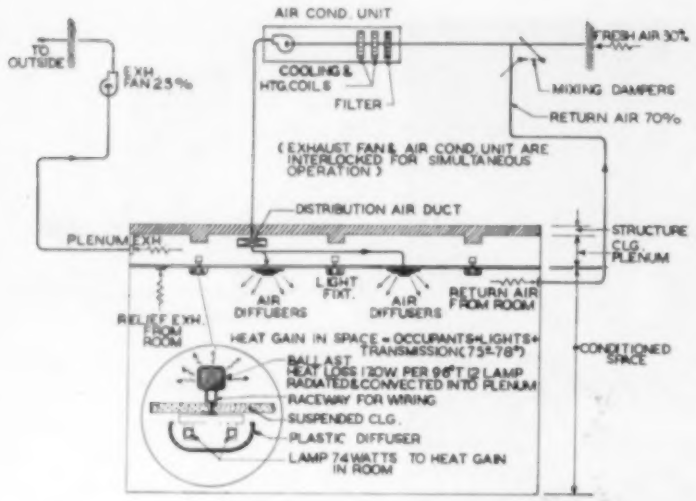

Figure 5. Relation of air conditioning to lighting elements.

In a large office installation of 100,000-square-foot area, which would require approximately 400 tons of refrigeration, the savings would amount to $16,728 or approximately 16.73 cents per square foot of floor area.

Sturrock and Schutrum conclude in their paper[1] that, "When these direct types of luminaires are built into a ventilated ceiling with glass or plastic bottom plates, or are installed above a ventilated false ceiling, it seems evident that the low temperature radiation and convected heat transferred into this room will be considerably less than obtained from luminaires suspended below the ceiling." It is assumed that this conclusion could be expanded to include "luminaires *attached* to the ceiling," as in the case of integrated ceilings, and would be reflected in savings in tonnage as described above.

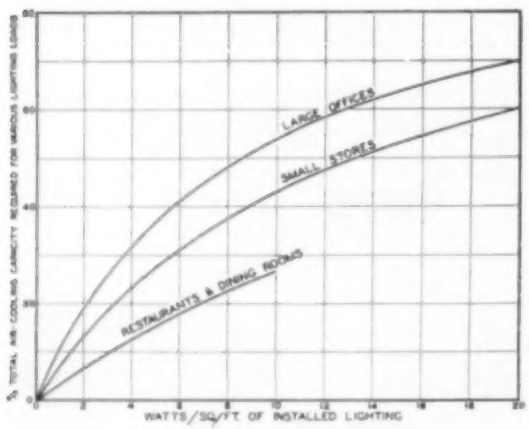
% TOTAL AIR COOLING CAPACITY REQUIRED FOR VARIOUS LIGHTING LOADS
LARGE OFFICES
SMALL STORES
RESTAURANTS & DINING ROOMS
WATTS/SQ/FT. OF INSTALLED LIGHTING

Figure 6. Effect of lighting load on air cooling capacity. (Reprinted by permission of the authors, from Sturrock, Walter, and Schutrum, Lester F., "A Study of the Extraction of Heat from Fluorescent Luminaires in Air Cooled Rooms," ILLUMINATING ENGINEERING, Vol. LII, No. 11, page 569 (November 1957).

To cite an unusual example, but not an uncommon one, the investor in buildings or owner is usually faced with the problem of whether or not he can afford a quality lighting installation with a "ceiling," referring to the usual dry type of suspended "false ceiling." The exposed detail of steel framing, or wood construction, with ducts, pipes, conduits, beams and girders is not desirable as a ceiling, for both aesthetic and practical reasons.

Table I shows a tabulation of costs made recently in connection with a large office for an aircraft manufacturer on the West Coast and illustrates the *hidden cost* factors, which make it possible to build a first class installation with good illumination, at no increase in cost, or in some cases at a savings in cost.

The following is a clarification of cost items included in Table I:

Item 1 in estimate in Table I is based on vermiculite roof on corrugated steel sheets, and includes both transmitted and solar heat gain. In the case of the integrated ceiling, the heat gain is reduced by the added insulation provided by the ceiling (1-inch Fiberglas).

Item 2 in estimate in Table I is based on 3.0 watts per square foot derived from two 96-inch slimline lamps at 8 feet on center in continuous rows. Savings with integrated ceiling reflects reduction of ballast heat gain.

Item 3 in estimate in Table I reflects the reduced room volume with a suspended ceiling as opposed to the same room without a ceiling. The reduced room volume reduces the total air circulated and the proportional amount of fresh air required. Cost per ton of refrigeration is

TABLE I — Cost Breakdown for a Typical Air Conditioned Office, Showing Economics of Integrated Ceiling System.

Without Integrated Ceiling			With Integrated Ceiling		
1. Heat gain through roof	52 tons		1. Heat gain through roof	32 tons	
2. Heat gain — lighting	49 tons		2. Heat gain — lighting (less ballast losses)	41 tons	
3. Heat gain — fresh air (25% of room volume based on 8 air changes per hour)	72 tons		3. Heat gain — fresh air (25% of room volume based on 8 air changes per hour)	57 tons	
TOTAL	173 tons @ $600	$103,800.00	TOTAL	130 tons @ $600	$ 78,000.00
4. Cost of lighting 58,000 square feet @ 70c		40,600.00	4. Cost of lighting and integrated ceiling, 58,000 square feet @ $1.25		72,500.00
5. Painting ceiling cavity — two coats white		14,250.00	5. Painting ceiling cavity (none required)		
6. Insulation of ductwork (none required)			6. Insulation of ductwork		4,500.00
		$158,650.00			$155,000.00
		155,000.00			
NET DIFFERENCE IN COST		$ 3,650.00			

average nominal for complete system including ducts, refrigeration, fans and controls, for simple single duct system.

Item 4 in estimate in Table I in case of room "without ceiling covers cost and installation of RLM 20 per cent uplight, two-lamp 96-inch slimline luminaires in continuous rows, 8 feet on center as opposed to cost of a two-lamp continuous luminaire with acrylic plastic enclosure, with maximum brightness of 600 footlamberts. Ceiling cost is included as part of lighting cost in the case of integrated ceilings and includes suspension system and 2-foot x 4-foot x ¾-inch white finished Fiberglas panels.

Item 5 in estimate in Table I covers cost of painting roof cavity, pipes, ducts and underside of roof, two coats white.

Item 6 in estimate in Table I covers cost of 2-inch Fiberglas insulation on ducts above ceiling. In the case of "no ceiling," the ducts are exposed in the conditioned space and so do not need to be insulated.

Other cost factors, walls, floors and other internal heat gains are the same in either case and hence are not included in the cost comparison.

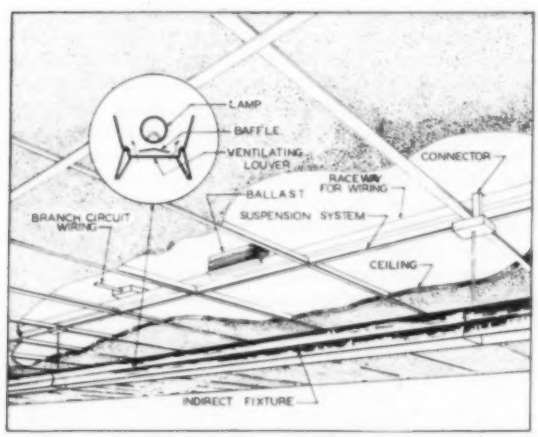

Figure 7. 1500-ma lamp application for indirect lighting.

High Output Fluorescent Lamp Application

"Integrated Ceilings for Illumination" point to a method of practical and economical application for the new 1500-ma lamps for general interior lighting. 80- to 100-footcandle, indirect lighting installations, sometimes referred to as "poor man's" luminous ceiling, can be provided through use of fixtures of a type illustrated in Fig. 7. The problems of ballast noise and ballast ventilation are solved by use of the ballast mounted in the ventilated ceiling plenum. With acoustical fiber ceiling panels, ballast noise is reduced to acceptable levels. Ballast heat is dissipated into the ceiling plenum and does not become a part of the air conditioning load.

Conclusions

(1) By analyzing the illumination and air conditioning heat gain factors in a modern building, and through careful integration of design elements, savings in costs of air conditioning can be used to justify improved illumination.

(2) Heat gain in air conditioned spaces from lighting can be reduced approximately 17 per cent of watts input into lighting system, resulting in savings in air conditioning costs.

(3) General lighting application of 1500-ma high output fluorescent lamps in offices, drafting rooms, etc., to provide comfortable high level indirect lighting levels at low cost is possible and practical with the application of integrated ceiling systems for illumination.

References

1. Sturrock, Walter, and Schutrum, Lester F.: "A Study of the Extraction of Heat from Fluorescent Luminaires in Air Cooled Rooms," ILLUMINATING ENGINEERING, Vol. LII, No. 11, p. 569 (November 1957).

2. General Electric Application Engineering, *LS-101*, April 1957.

DISCUSSION

W. F. Blitzer:* This is an interesting paper. Its importance lies largely in its general over-all approach to the subject of environmental control rather than the specialized lighting approach which we so often deal with. In this day of specialists, it is indeed a good thing to hear occasionally from a "generalist."

The particular example which the author gives, of a large one-story office building, incorporates factors which might well exist with other lighting systems. Most of the savings arise from the use of a hung ceiling per se, that is, the elimination of the painting of ceiling cavity, the reduced heat gain through the roof and the reduced volume of the air-conditioned space. These savings are more dramatic than would be the case in multi-storied construction where, for example, heat gain from the roof would be a much less important consideration.

It is true, of course, that the advantages cited which result from placing the ballast above the hung ceiling also occur if recessed equipment is used rather than surface equipment with a remote ballast as in the system described. It has been our experience that when a hung ceiling is installed, there is a general preference for recessed equipment rather than surface equipment. We have also found that if shielded lighting is required and larger diffusers of lower brightness are in mind, that the cost of recessed lighting is not appreciably higher than that of the system which is described.

One limitation of the system at present is that it is available only for exposed grid ceilings which many architects and others do not care for because of the appearance of the pronounced pattern on the ceiling.

There is another limitation which is that as compared to recessed equipment which is simply "laid into" an opening in an exposed grid ceiling and which can be connected to an outlet box by a length of flexible conduit, there is a restriction on flexibility in the system described, due to the necessity of locating the fixtures directly below the raceway. While the raceway can be moved, if desired, this will generally entail quite a bit more work than moving a "lay-in" troffer.

The author mentions the use of this new system with high-output lamps. This would certainly seem to be an important application for this idea, due to the heat and noise problems associated with the new high intensity sources, which are making appreciable inroads into the fields of office, library and drafting room lighting among others.

W. F. Spiegel:** The author has presented what is fundamentally an advanced idea, but the assumptions made in computing the cost figures appear to be unsupported by any real tests. Fresh air does not necessarily vary with building volume, but even assuming that a particular design required the quantities stated, it does not appear feasible to have 25 per cent of the exhaust air absorb 100 per cent of the heat rejected by the fluorescent lamp ballasts. A certain percentage of the heat will always be transferred into the room down through the ceiling. It is difficult to envision from Fig. 5 how the air from the room could reach all of the affected ceiling areas without a rather elaborate system of return grilles for allowing the air to penetrate the ceiling at random, with the resultant problem of periodic cleaning.

From the air conditioning point of view, it would be very desirable to have more information on the system, particularly some data on the actual thermal performance.

W. S. Fisher:* We are pleased to find others concerned with this vital matter of the relationship between lighting and air conditioning. It is also gratifying to see practical methods of approaching this problem such as the one found in this paper.

Now that we have a basis for specifying more realistic and more adequate lighting levels in commerce and industry, many lighting engineers will be faced with the challenge of better coordination of lighting and air conditioning systems. While conventional methods of air conditioning can be used to handle the heat loads created by lighting systems providing as much as 1000 footcandles, this is a brute force method of accomplishing the desired cooling. Furthermore, there will be many customers for lighting systems in the future who will settle for less illumination than needed because their budgets will not stand the lighting costs together with the additional costs imposed by air conditioning. Considering initial equipment costs only, for every dollar spent for lighting, about 75 cents must be spent for the air conditioning necessary to take care of it. A major challenge before us is to coordinate lighting and air conditioning in our ceiling systems so that costs are minimized.

Mr. Hamel points the way to a very significant method of reducing air conditioning costs; that is, using air that is normally bled off from the system to cool the ceiling cavity and the ballasts which are located there. While the example analyzed in the paper is that of a single-story commercial building having considerable solar heat gain through the roof, this scheme would also be practical for a multi-story building having suspended ceilings and say, conventional troffer lighting. In troffers, as much as 75 per cent of the watts input to the luminaire is in the form of or is reduced to long wave infrared which heats the surrounding air and luminaire parts. This heat is available for transfer outside the occupied space before it becomes a load on the air conditioning system through methods similar to that described by Mr. Hamel.

One would suspect that the 17 per cent figure given for heat removal due to the location of ballasts in the ceiling cavity is a conservative figure. Lower cavity temperatures should result in lower temperature of ceiling parts and provide for more rapid heat transfer in this direction from surface mounted or suspended lighting units. The higher the proportion of upward light from the luminaires, the more effective heat removal through the cavity would be. Furthermore, the lower ceiling temperature should reduce the radiant heating effect of the ceiling and permit somewhat higher room air temperatures for the same effective skin temperature of the occupants. Is this a significant factor, and has it been considered in the design of any integrated systems?

In the case of continuous row troffer lighting, there is an opportunity to withdraw the air from the occupied space through the troffers, connect a duct to the troffers and exhaust the air to the outside. This scheme, involving the use of high output lamps in the troffers is presently being installed in the area devoted to office lighting at the General Electric Lighting Institute at Nela Park. Lighting levels in excess of 500 footcandles will be provided (see

*Lightolier Inc., Jersey City, N. J.

**Research Laboratory, American Society of Heating, Refrigerating and Air Conditioning Engineers, Cleveland, Ohio.

*General Electric Co., Cleveland, Ohio.

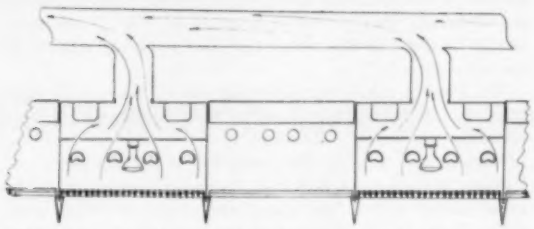

Figure A. In this continuous row troffer lighting installation, air is withdrawn through the troffers, then exhausted through a duct connected to troffers.

Fig. A). Air velocity past the lamps is controlled to carry off all the long-wave infrared output of the lamps together with much of the radiant energy which is absorbed by the luminaire itself. It is anticipated that more than 50 per cent of the watts input to the luminaire can be removed in this manner. This installation is expected to provide much valuable information concerning the relationship of lighting and air conditioning.

BILL F. JONES:* Mr. Hamel's paper is a definite step in the direction of synthesis of the luminous, thermal and acoustic environments, placing proper emphasis on the consideration of the problem as a whole instead of as unrelated parts, which has often been the case in the past. The benefits to be gained by integrating these systems into one unit are numerous.

In performing this integration, however, we should not lose sight of the necessity for maintaining quality in each of the systems, and not compromise simply for ease of integration. From the lighting standpoint, this has been the major flaw with all of the currently manufactured integrated ceilings. Not one of the systems pictured in the photographs will meet the current office lighting practice. The bare lamp system, while excellent for markets, has only economy in its favor for other types of installations. The plastic-enclosed units are far too bright from a direct glare standpoint. In the interests of economy, the recessed types have always been made very narrow, and an attempt has been made to get as much light as possible out of the narrow channel, resulting in low efficiency, high reflected glare, and (in the case of the dropped panel type) high direct glare.

This does not mean that quality lighting cannot be obtained with integrated ceilings. It most definitely can, and Fig. 7 gives one excellent approach. Unfortunately, this also gives a higher cost. In the surface and semi-recessed applications, quality can be obtained by using more area and closer attention to lighting principles. These also will undoubtedly raise the cost. On several occasions I have been asked by a client how he could improve the quality of his integrated ceiling, with which he was not satisfied. On each occasion the solution has been considerably more expensive than would have been the case had the manufacturer designed his system for lighting quality in the first place.

G. H. PERRY:** Perhaps Mr. Hamel has had opportunity by now to consider the merits of high-frequency lighting. The paper, "Design and Application of a New High Frequency Power Source for Fluorescent Lighting" by Messrs. Johnson, Winpisinger and Roesel certainly pointed up several virtues of their system which parallel those mentioned by Mr. Hamel in favor of the integrated ceilings for illumination which he discussed. In the case of the former paper, an obviously-desirable condition for the described frequency converter would be exterior to the room proper, by locating units, together with associated ballasts, above the false ceiling. The fact that the former paper dealt with a rapid-start system while the latter dealt with a slimline system matters really little. A metal reflector plate is available for the first of the two-surface-type systems described, and the more efficient rapid-start system should therefore function without any problem. With the further reduction in heat loss, *i.e.*, with the increased efficiency of the high-frequency system, it would be interesting to obtain Mr. Hamel's views as to whether or not such a composite integrated system would further reduce the prime and operating costs of air conditioning equipment.

Here is another consideration. The lamps could be located *above* the ceiling. The suspended ceiling panels could be replaced by translucent plastic panels. These changes would result in creating a luminous ceiling, which is generally accepted as the best condition of lighting. But, the *added* benefit of doing this would be that the heat produced by the lamps would also be dissipated directly into the plenum chamber. Essentially, all heat produced by the lighting system could thereby be easily removed by the plenum exhaust fan.

As a final point, I am wondering whether provision could be made for reclamation of the dissipated heat during the winter months. If so, could such a process reduce the prime and operating costs of heating equipment substantially?

I believe the above considerations should be made in gaining further calculable economies with such installations.

J. S. HAMEL:* Mr. Blitzer's comments on the subject matter of the paper are well taken, but are concerned largely with specific details of the type of equipment covered in the paper. It was the intention of the paper to bring to light the economics involved in the integration of lighting equipment with ceilings in general, and while specific items might be mentioned categorically in connection with the system as indicated, the implication is of a broad nature and therefore, should not be concerned primarily with specific details. I agree that many suspended ceiling systems naturally adapt to recessed equipment; however, it should be pointed out that economics dictate the less expensive surface mounted unit in most cases.

I agree with Mr. Spiegel that certain portions of heat from the ballasts would be transmitted through the ceiling; however, the figures used in the heat emanation from the ballasts are so conservative that any variation in this respect would be more than absorbed by the conservativeness of the figures.

The question of quantities of fresh air used in buildings varies with occupancy and location of structures. It should be noted, however, that a general rule of thumb of 25 per cent of total air is considered to be good standard practice for the majority of office air conditioning jobs.

Mr. Spiegel's comment on how the air gets into the ceiling is interesting, but rather simply answered inasmuch as ceiling grilles are installed in ceilings of this type at random points throughout the ceiling areas to provide for adequate breathing action between ceiling and floor and to

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**Canadian Westinghouse Co., Ltd., Lighting Division, Granby, Que.

*Author.

allow for the air exhausted from the ceiling plenum space to be replaced by room air through a fairly uniform distribution of such ceiling grilles.

The reference to cleaning in Mr. Spiegel's discussion is not quite clear. Does he mean cleaning of the luminaires or cleaning of ceiling grilles?

I am pleased to have Mr. Fisher's discussion and have only one comment. His comment relative to lowering of ceiling temperature and reduction of radiant heating effect of the ceiling is very questionable insofar as internal design conditions of this space are concerned. This is not really a significant factor and could scarcely be put down in terms of finite thermal units without rather elaborate test data.

I would like to thank Mr. Jones for his very interesting appraisal of the paper. I agree that many of the manufacturers of integrated lighting systems for ceilings do not have properly designed luminaires at this time. My feeling is that this phase of lighting application will grow and improve as the system develops and there is much to be done, with much improvement to be made in connection with luminaires as now available from manufacturers of integrated ceiling systems.

Mr. Jones' questions relative to costs in the application of the high output lamp of non-circular cross section in indirect systems are subject to some controversy. Since a system of this type has not yet been built, it is difficult to say definitely that it will cost more or less. Much work should be done in this connection and probably will be in the near future.

Mr. Perry's comments regarding the application of high frequency lighting in connection with integrated ceilings certainly are timely. However, it is my opinion that the savings in heat gain in the space, due to the elimination of ballasts in connection with high frequency lighting, could be accomplished without the use of an integrated ceiling principle. There is no question that the removal of the converting equipment and ballasts, remote from any system of fluorescent lighting, will certainly remove the heat of these devices from the space which is being illuminated.

Mr. Perry's question as to whether or not this heat could be used in the winter months for reducing the heating requirements for a structure can be answered in the affirmative, provided that a satisfactory air heat exchanger can be developed for transferring the heat energy from the exhausted air into the incoming fresh air. Such an air-to-air heat exchanger is currently being developed by a company on the West Coast, and someday in the future may be a reality. At the present time, however, there is no satisfactory and effective air-to-air heat exchanger available to effect this type of heat exchange.

Boundary Lighting for a Country Estate

Going garden lighting one step further, the owner of this country estate in Georgia has illuminated the fence enclosing his acres. The fence, which is white, is of the "Kentucky" or "Union Jack" type and is used as a reflecting surface. The lighting unit consists of a porcelain weatherproof socket with an 8-inch semi-parabolic specular aluminum reflector, using a 10-watt inside frosted lamp. Units are mounted on the cross-bars of the fence on 10-foot centers. Illumination is 5 footcandles.

The lighting is controlled by a time clock to go on at dusk and off at 11 or 12 p.m. For special holiday or Christmas lighting, red, blue, green and amber lamps have been used for decorative color effects.

In addition to its decorative and safety features, the lighting of the fence has produced a financial advantage. Since much of the fence encloses a cow pasture for registered Guernseys, the extra hours of light have increased milk production.

This installation, by Robert J. Kuzell, Kuzell and Co., Decatur, Ga., won honorable mention in the national MMILJ contest, having previously taken top honors in the Georgia Section and the Southeastern Region.

Prediction of

Illumination Under Downlights

By ISAAC GOODBAR

New charts making possible immediate comparisons between the illumination levels at several critical points, under downlights of any candlepower distribution.

DOWNLIGHTS, alone or supplemented with other types of lighting, to illuminate extensive areas are becoming ever more common. These fixtures are generally designed so as to throw most of their light output in the zone between nadir and a definite maximum angle from the vertical. High brightness at normal viewing angles is, therefore, avoided.

Several methods of calculation are available for this type of illumination, such as the flux method and the interreflection method. These methods make possible the quick and simple determination of the average illumination on a horizontal working plane. This average illumination may differ from the real illumination at each point by variable amounts depending on the spacing between units, and their candlepower distribution as related to their height above the working plane.

Very often it is necessary to know the illumination changes at different points of the working plane. When the manufacturer's recommendations regarding ratios of spacings to heights above working plane can be followed, a reasonably uniform illumination can be expected. Often it is found that these recommendations cannot be followed for architectural or other reasons. Then it becomes necessary to know how far from uniform the illumination will really be. When a choice between several possible fixtures has to be made it is indeed desirable to know which of them will light the plane. When the manuacturer's recommendations given area with maximum uniformity.

The only method that will supply these answers is the point by point method of calculation. This method, however, is inherently laborious. Shortcuts are available (including some developed by this author, ILLUMINATING ENGINEERING, Vol XLI, January 1946, pages 39-76). Even these shortcuts may require more time than is generally available, especially when comparisons between many possible units have to be made.

For these reasons it was considered that some new method requiring no more work than is normally required for average flux computations, but based on point by point calculations, would be desirable. These would supplement other available methods of calculation, making it possible to predict variations of illumination on several critical points.

This paper presents a method, based on point by point calculations, which makes possible the immediate determination of relative illumination values, in several critical points on the working plane, without performing even a single arithmetical op-

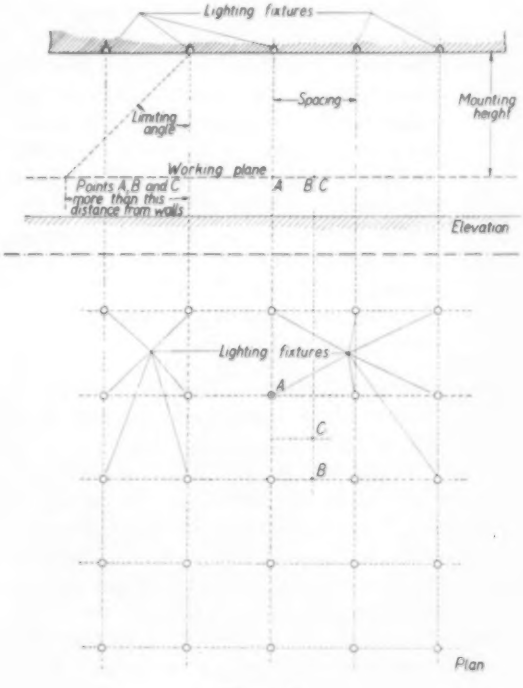


Figure 1.

AUTHOR: Illuminating Engineer, New York, N. Y. Developed in connection with consultation work for Edison Price, Inc.

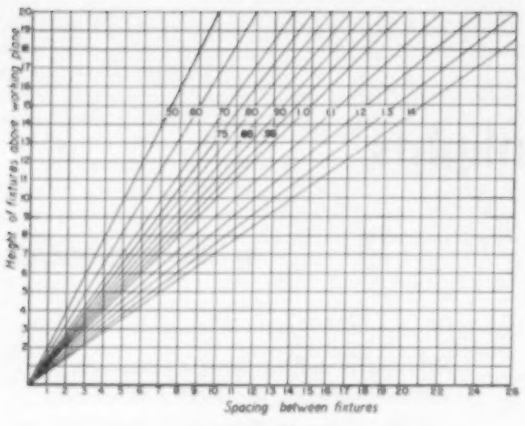


Figure 2.

eration. These methods are limited to the following situations:

(a) The units emit most of their light output only up to a certain limiting angle with nadir. The flux emitted beyond that angle is relatively small and can be neglected. In the charts presented (Figs. 3 and 4) this angle is always larger than 45 degrees.

(b) The units are located in a regular pattern, forming simple geometric figures (such as squares, rectangles, triangles, parallelograms, triangles or hexagons). In the charts presented the units are assumed to be located in the vertices of squares (Fig. 1).

(c) The points considered are located at a distance from the walls large enough so that a lighting fixture exactly over them would not send any light to the walls, above the working plane, except at angles beyond the limiting angle mentioned. In the charts presented, the points considered, A, B and C (Fig. 1), are assumed to be located at a distance from the walls larger than the mounting height (height of fixtures above working plane).

Many practical situations, involving downlights, will fall within these limitations, so that these methods will often be found applicable.

In the first part of this paper, the new charts are presented and their use explained. By means of the charts of Figs. 2, 3 and 4, the relative illumination on points A, B and C will be obtained without doing a single computation. These values will be proportional to the total illumination on the points considered, only if the fixtures send no light beyond the limiting angle and if reflections from floor, ceiling and walls are disregarded. When the problem consists in the comparison of several different fixtures, as these factors are all bound to improve the uniformity, they may be safely disregarded.

The chart of Fig. 9 makes it possible to translate these relative values into absolute values of illumination. In general this will not be necessary as the average values can easily be determined by other methods, as mentioned above. In this paper, particular application of the charts to square patterns is considered. In its second part how to prepare similar charts for other situations is explained, always involving square patterns. Only the charts of Figs. 3 and 4 may have to be prepared especially for special situations; Figs. 2 and 9 are completely general and applicable to any situation or pattern. Finally, in the Appendix, the mathematical basis of these methods is presented, as well as their application to different types of geometrical patterns.

Part I — Presentation of the New Charts

The technique presented is based on the use of the charts of Figs. 2, 3, 4 and 9. Of these, only those of Figs. 3 and 4 are basically new. Figs. 2 and 9 have only the purpose of avoiding some simple numerical operations, making possible the entire computations without any arithmetic whatsoever.

All that is required to determine the illumination on the points *A*, *B* and *C* of the working plane, is a candlepower distribution curve drawn to any scale (such as the one shown in Fig. 5), preferably on a transparent or translucent paper. This is generally available from manufacturers.

The illumination will be determined by means of the three following simple steps. When only relative values are needed, as will be the case when comparisons between several units have to be made, or when the average values are determined by other methods, only the first two steps are required.

(a) *Determination of the ratio of spacing to mounting height:* This ratio can be determined immediately by means of Fig. 2, entering the proper spacing and mounting height in the horizontal and vertical scales, and reading in the diagonal lines.

For instance, if the mounting height is 11 feet 6 inches and the spacing is 9 feet 2 inches, it is found that the ratio is, very approximately, 0.80.

Of course, the use of Fig. 2 is only intended to avoid one division. If so desired, this figure may be disregarded and the division of the spacing by the mounting height performed by slide rule or other known procedure.

(b) *Determination of relative illumination readings,* proportional to the illumination: For the ratio of spacing to mounting height, select the ap-

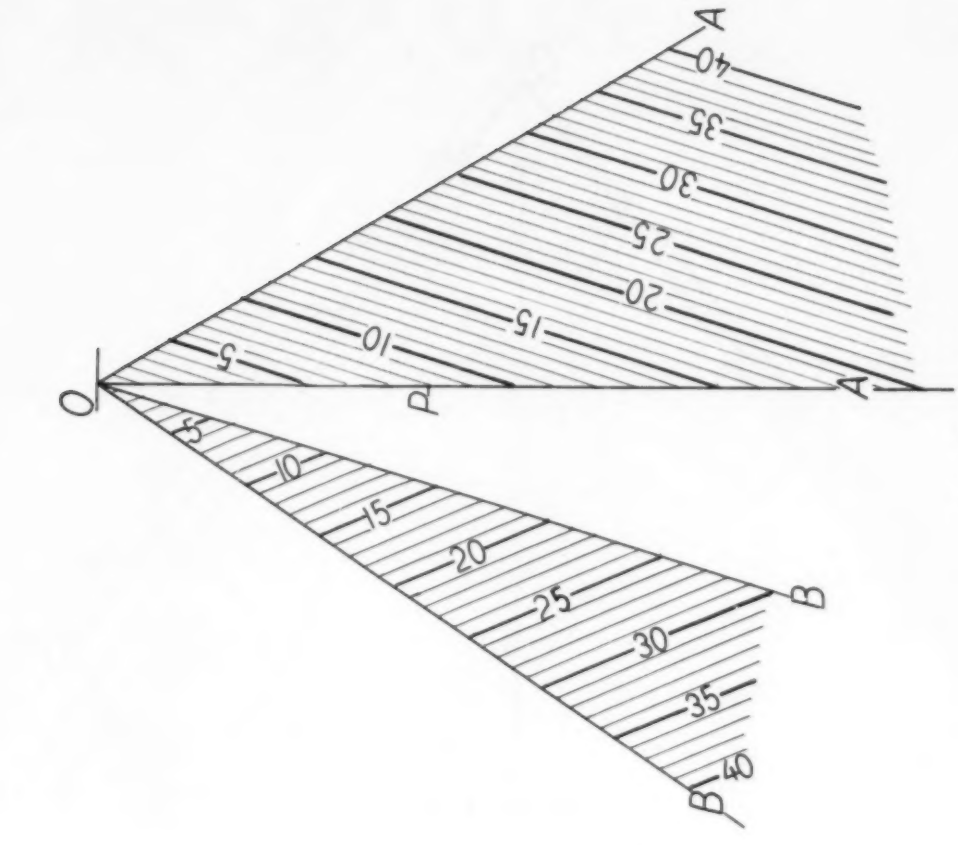


Figure 3b. S = 0.6.

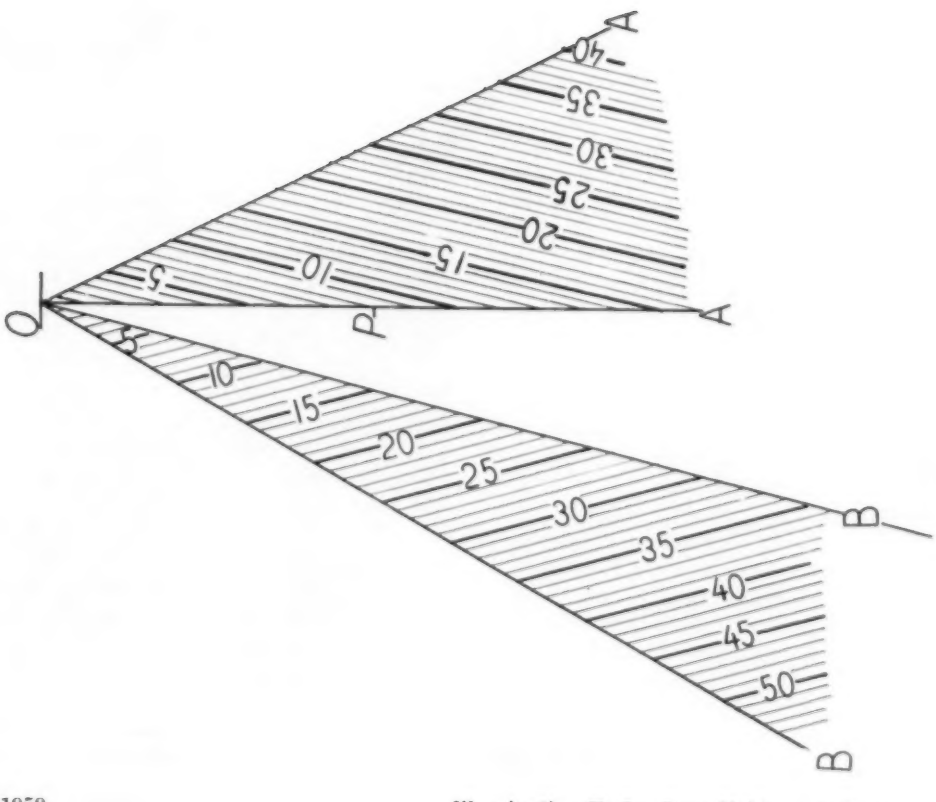


Figure 3a. S = 0.5.

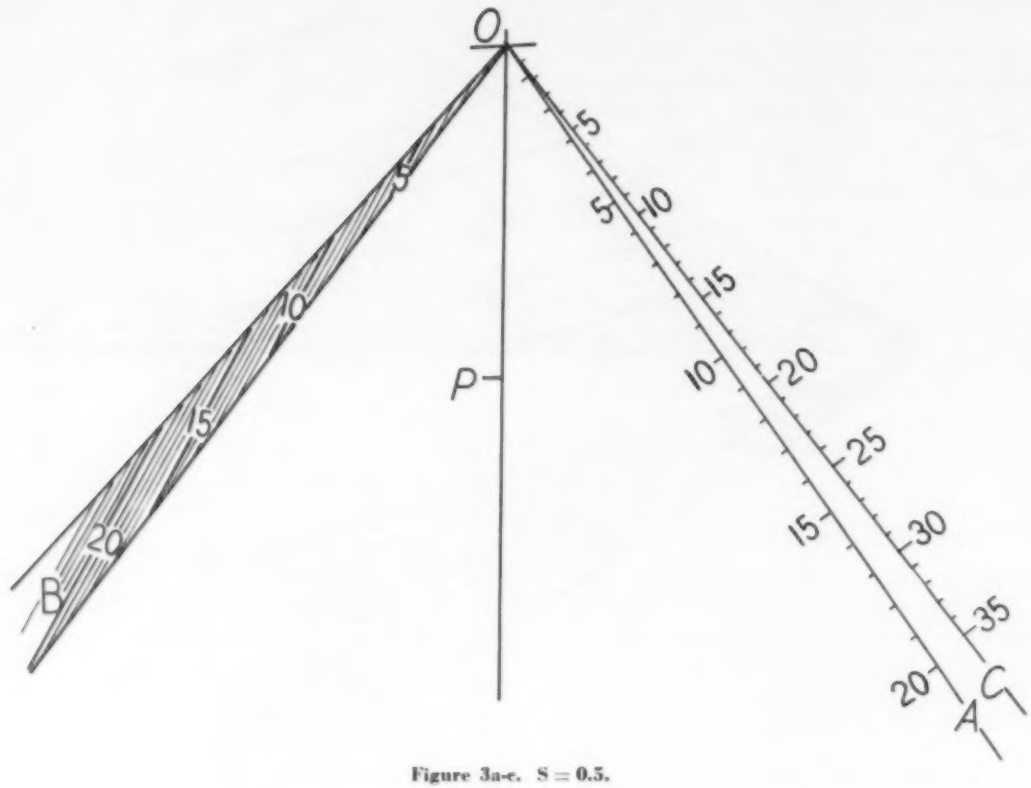


Figure 3a-c. S = 0.5.

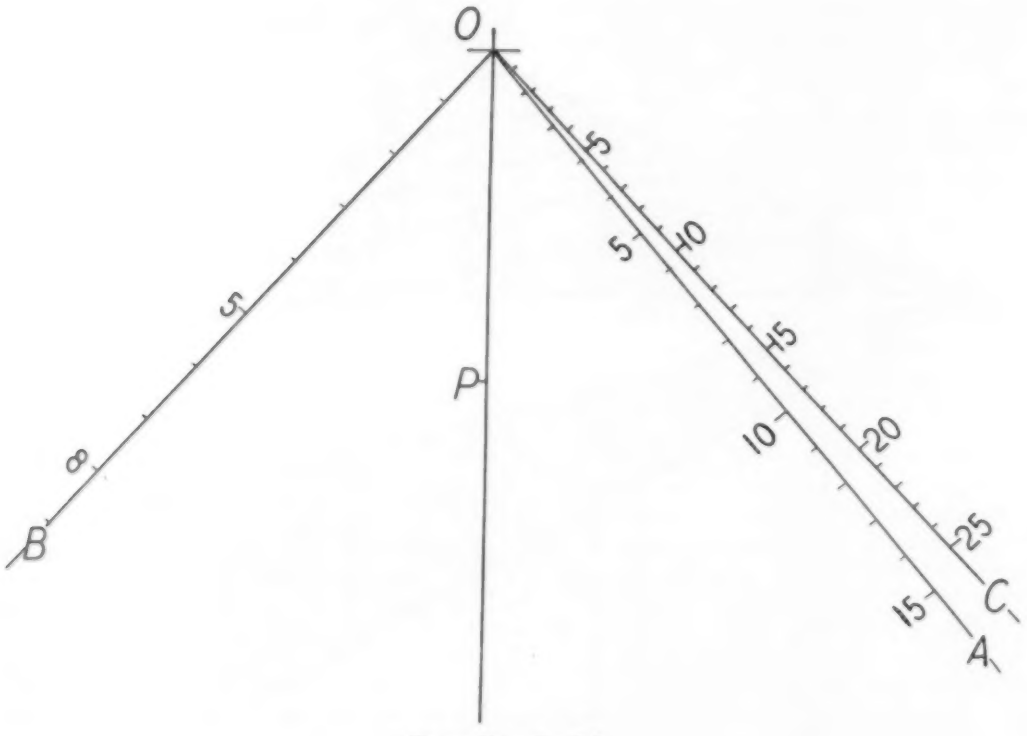


Figure 3b-c. S = 0.6.

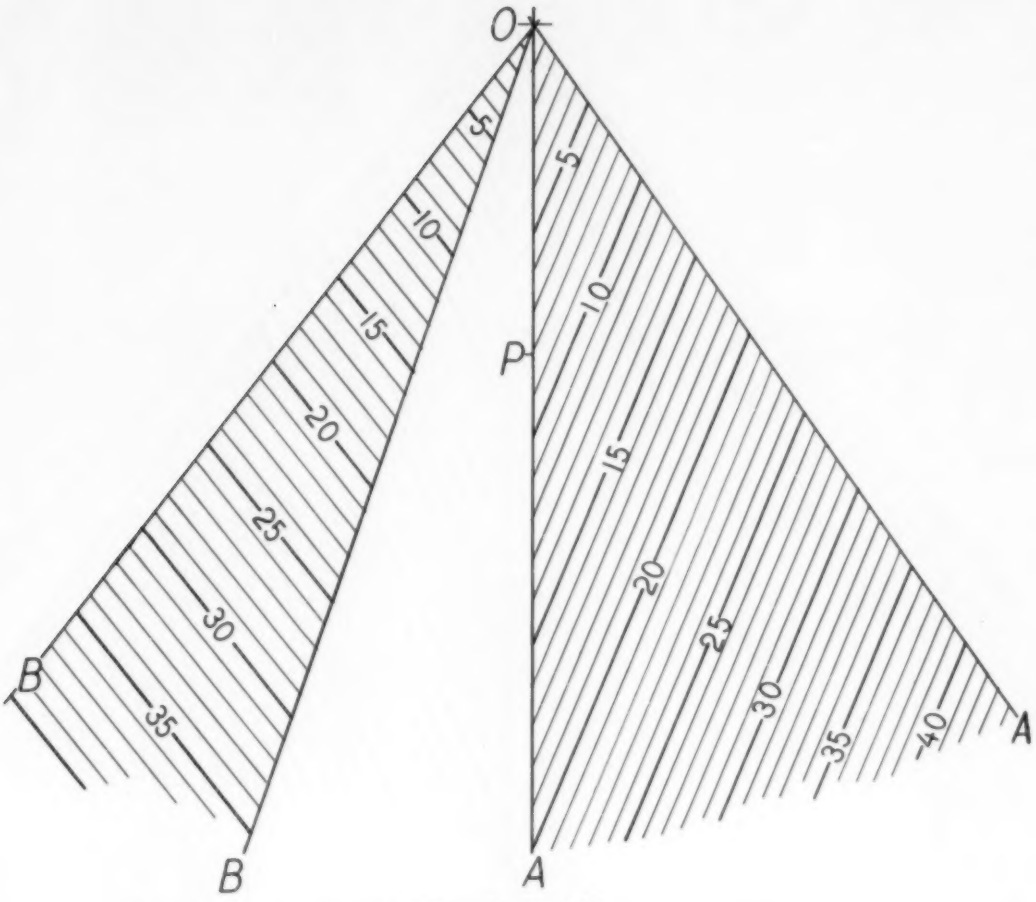


Figure 3e. S = 0.70.

propriate chart in Fig. 3. For the determined ratio 0.80, the corresponding chart is the one of Fig. 3e.

Lay the candlepower distribution curve, such as the one of Fig. 5, over Fig. 3e (as shown in Fig. 6).

Where the candlepower distribution curve cuts the lines *OA* of Fig. 3e, mark the points *a-a*. Read under point *A*, midway between *a-a*, a value, which will be called *relative reading*. In the case of Fig. 5, this relative reading for *A*, is 8.9.

Similarly, at point *B* (midway between the intersections *b-b* of the candlepower curve and the lines *OB*) the relative reading is 8.9. To obtain the relative reading corresponding to point *C*, lay the candlepower distribution curve (Fig. 5) over Fig. 4 (as shown in Fig. 7).

Where the candlepower distribution curve cuts the inclined straight line corresponding to the ratio of spacing to mounting height (in the example given 0.8) obtain the relative reading for point *C*. In Fig. 7, for the case considered, this relative reading is 9.8.

These relative readings are, respectively, proportional to the illumination at points *A*, *B* and *C* (Fig. 1) located, respectively: under a lighting fixture, midway between two fixtures and in the center of four fixtures. The illumination at any other point of the working plane will have, in general, some value between the extremes at two of these chosen points. In the case shown, the illumination at any other point of the working plane between *A*, *B* and *C* will not be larger than 9.8, nor smaller than 8.9 (relative readings) *i.e.*, it will not change by more than 5 per cent above or below an average value. It is, of course, assumed that the candlepower distribution curve, such as the one of Fig. 4, has no important discontinuities.

To avoid the drawing of the lines *a-a* and *b-b*, it is advisable to reproduce a scale such as the one in Fig. 8, on a piece of tracing paper. Laying this scale so that the same reading is obtained on it, at each of the points *a-a*, for instance, it will be possible to obtain directly, under its center, the desired relative reading.

When absolute values of illumination are also desired, take also the candlepower reading over point *P* (800 candles in the case shown in Fig. 6).

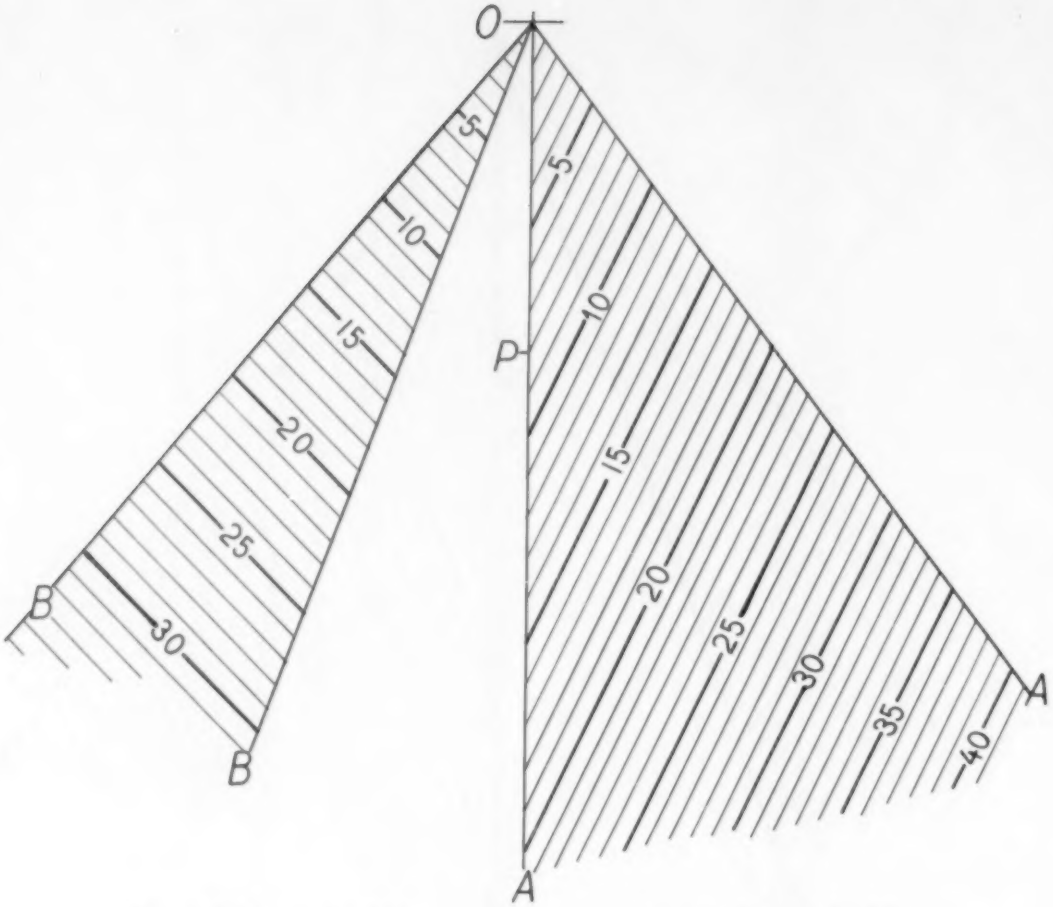
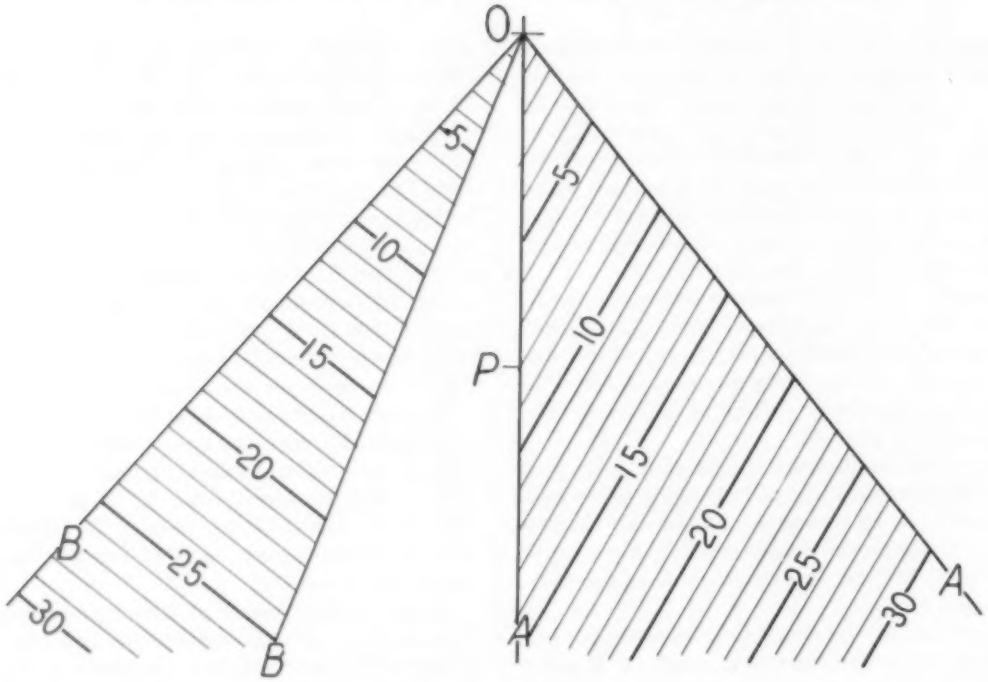


Figure 3d (above). S = 0.75.

Figure 3e (below). S = 0.8.



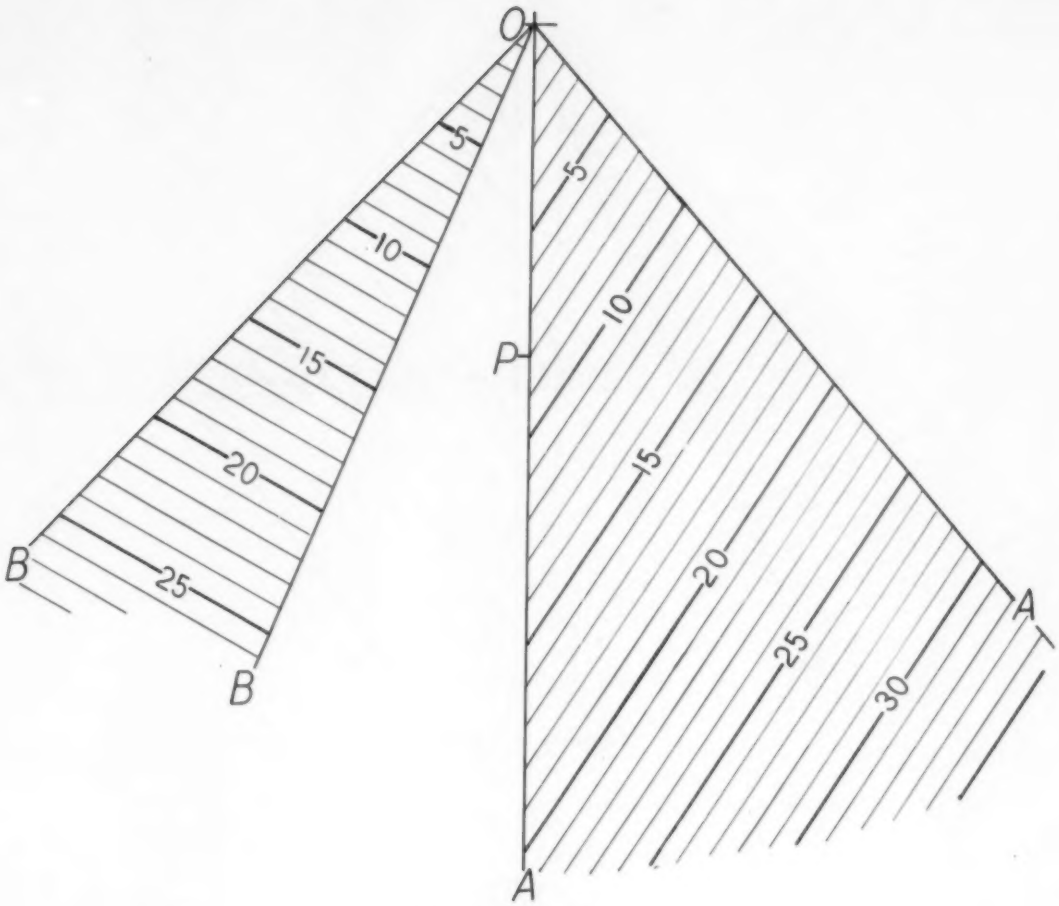


Figure 3f. S = 0.85.

This will be used in the following step.

As mentioned, all the charts in Figs. 3c, 3d, 3e, etc. up to Fig. 3m, as well as the chart in Fig. 4, give relative readings proportional to the illumination on points *A*, *B* and *C*, taking into account all the light emitted by the fixtures up to a limiting angle of at least 45 degrees from nadir.

Charts 3a and 3b (for ratios of spacing to mounting height equal to 0.5 and 0.6) as well as Fig. 4 (when used for ratios under 0.7) take into account the light emitted up to limiting angles of:

35 degrees from nadir for a 0.5 ratio of spacing to mounting height, and up to
40 degrees from nadir for a 0.6 ratio

Fixtures designed to be located at such close spacings will generally emit very little light beyond the above mentioned angles. However, if it is desired to take into account, even in these special cases, all the light emitted up to 45 degrees, the charts in Figs. 3a-c and 3b-c may be used. These charts, to be laid under the candlepower distribution curves, as explained, will give the relative readings due to the light emitted between the above mentioned limiting angles and 45 degrees. These readings must be added to those obtained in Figs. 3a and 3b, to take into account all the light emitted up to 45 degrees from nadir.

(e) *Determination of absolute illumination values:* Absolute illumination values can be obtained, when desired, by means of Fig. 9.

Enter the *candlepower reading at P* and the *mounting height*, in the horizontal and vertical scales of Fig. 9. Determine the corresponding diagonal line. For instance, if the candlepower at *P* had been 846 and the mounting height 11 feet 6 inches, the diagonal line 1.6 is determined.

Enter the relative reading in the right hand side vertical scale of Fig. 9. Follow a horizontal line from this point to the diagonal previously determined, then a vertical upwards. Read the illumination on the top horizontal scale. For example, if the relative reading had been 33, the corresponding illumination would be 53 footcandles, as shown in Fig. 9.

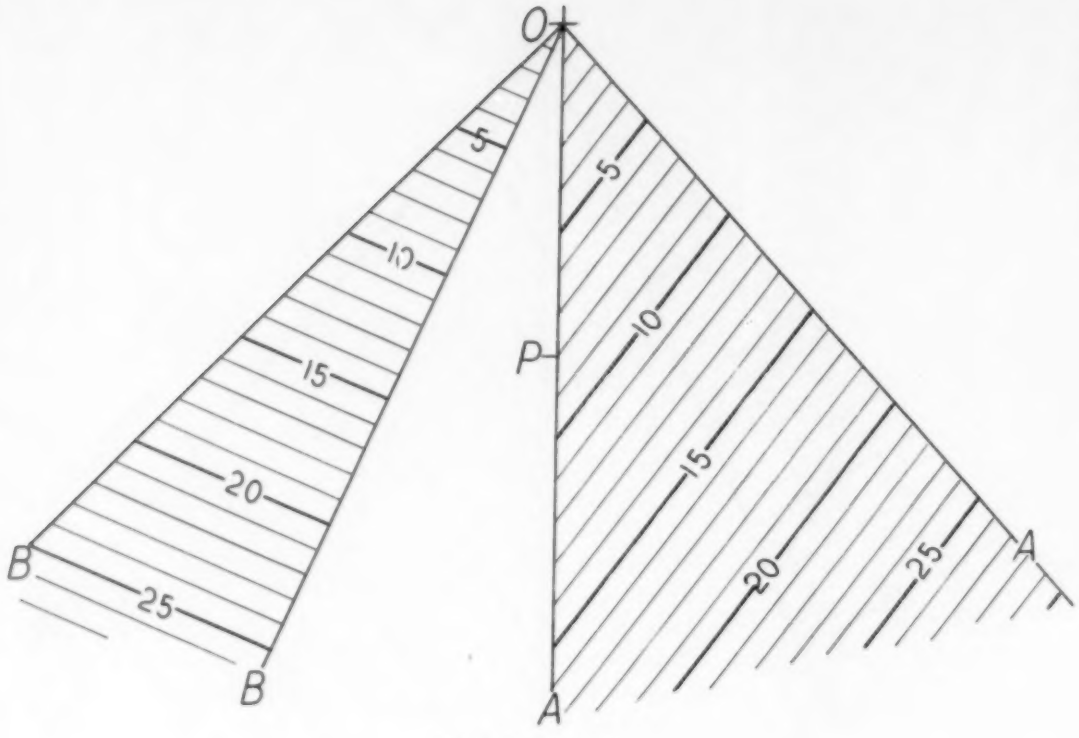


Figure 3g. S = 0.90.

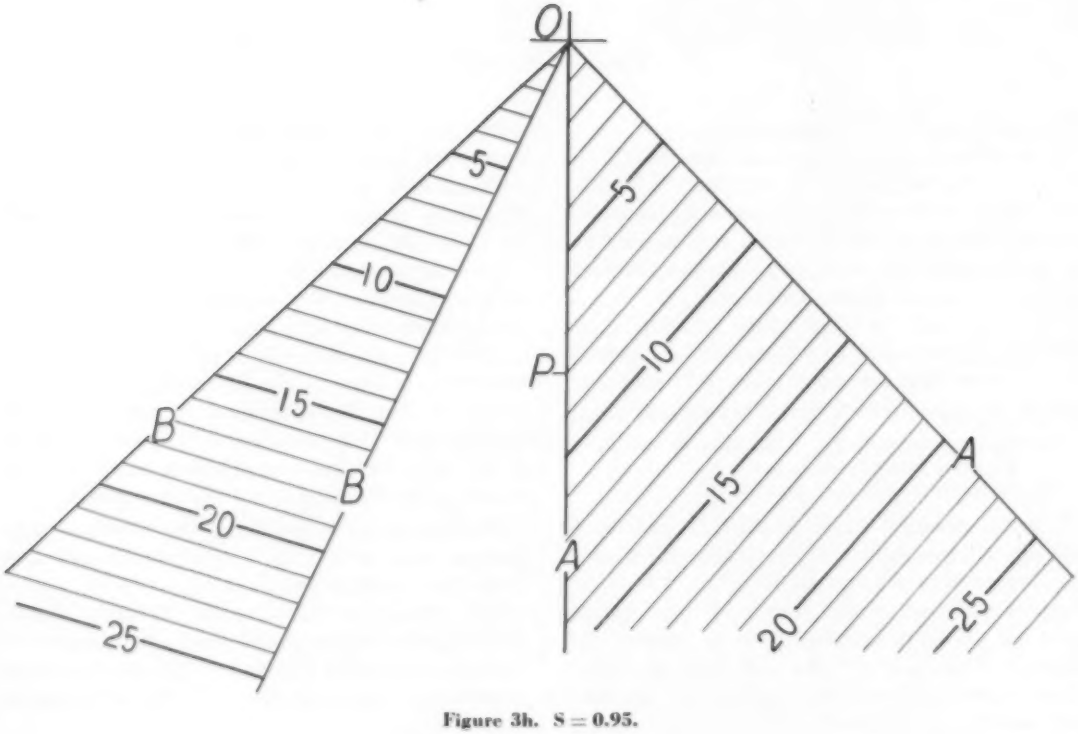


Figure 3h. S = 0.95.

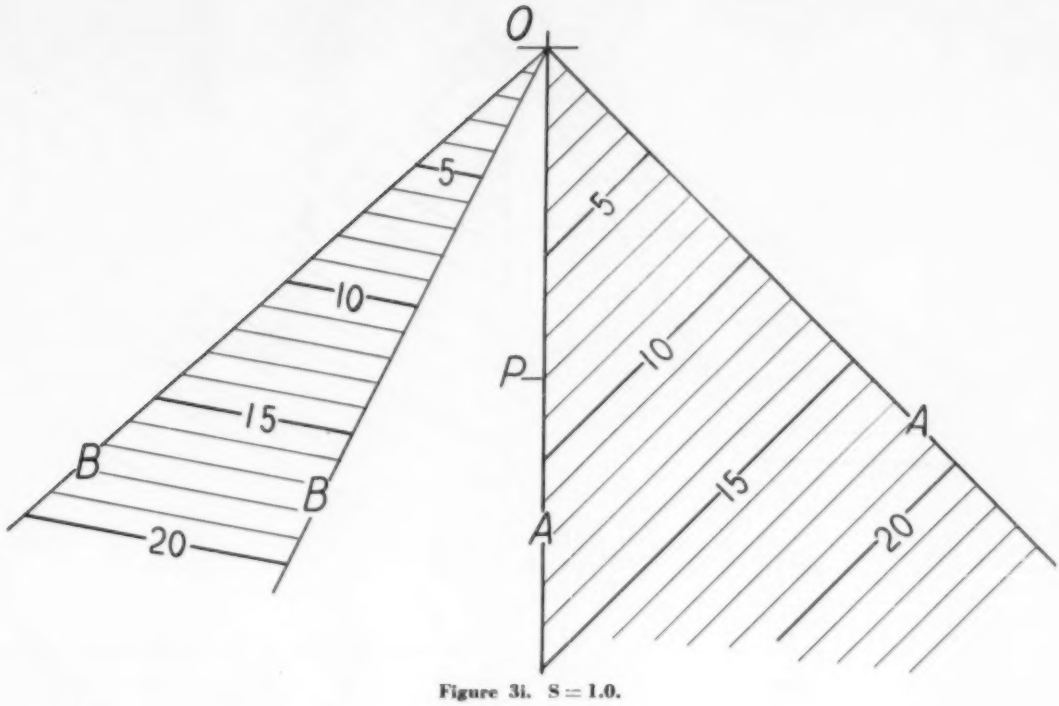


Figure 3i. S = 1.0.

Instead of Fig. 9, the following simple formula may be used:

$$E = \frac{I_p}{4H^2} R \qquad (1)$$

where:

I_p = candlepower reading at P

H = mounting height (Fig. 1) in feet or meters

R = relative reading obtained in the second step described (Fig. 5)

E = illumination (in footcandles or lux)

Formula (1) can also be written:

$$E = kR \qquad (2)$$

where:

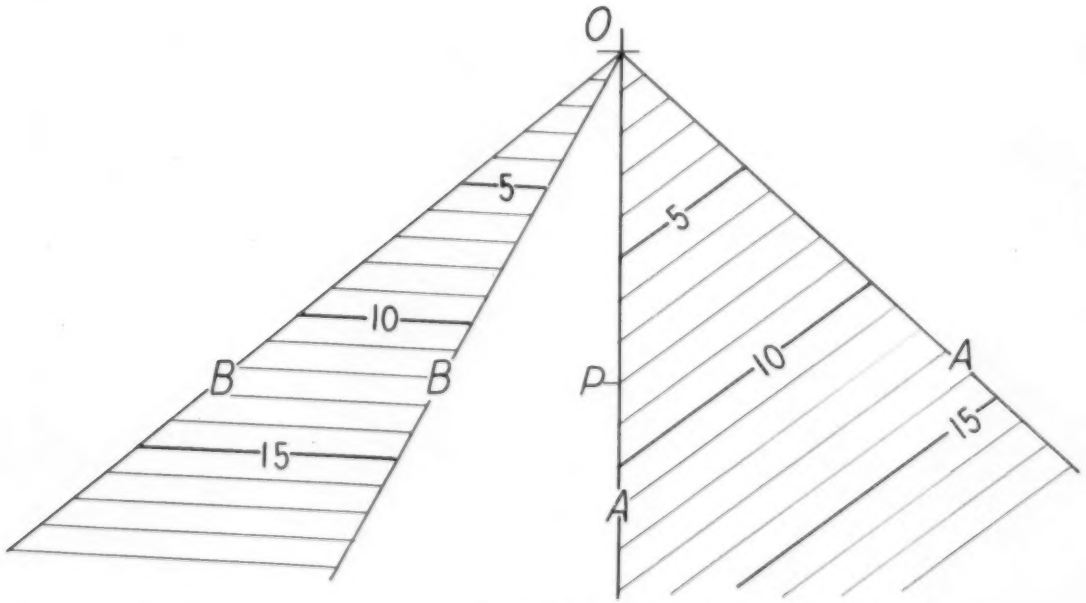


Figure 3j. S = 1.1.

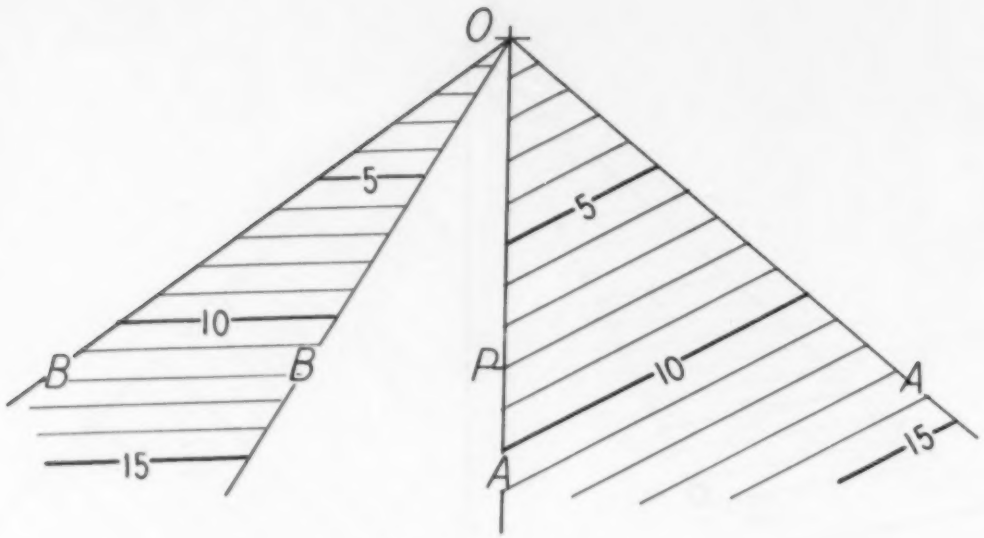


Figure 3k. S = 1.2.

$$k = \frac{I_p}{4H^2} \qquad (3)$$

In the example mentioned:

$$k = \frac{846}{4 \times 11.5^2} = 1.60$$

which was the value on the diagonal line determined in Fig. 6.

It is important to mention the fact that the multiplying factor k, determined by means of Fig. 9 or of formula (3) does not change if the mounting height and the scale of the candlepower distribution curves remain constant. In such cases all kinds of comparisons can be made very quickly between the same or different fixtures at many different spacings, as then the relative readings are representative, always in the same scale, of the absolute illumination values.

Part II — Preparation of the Charts Described

The mathematical basis of the charts presented is described in the Appendix. In this part only the

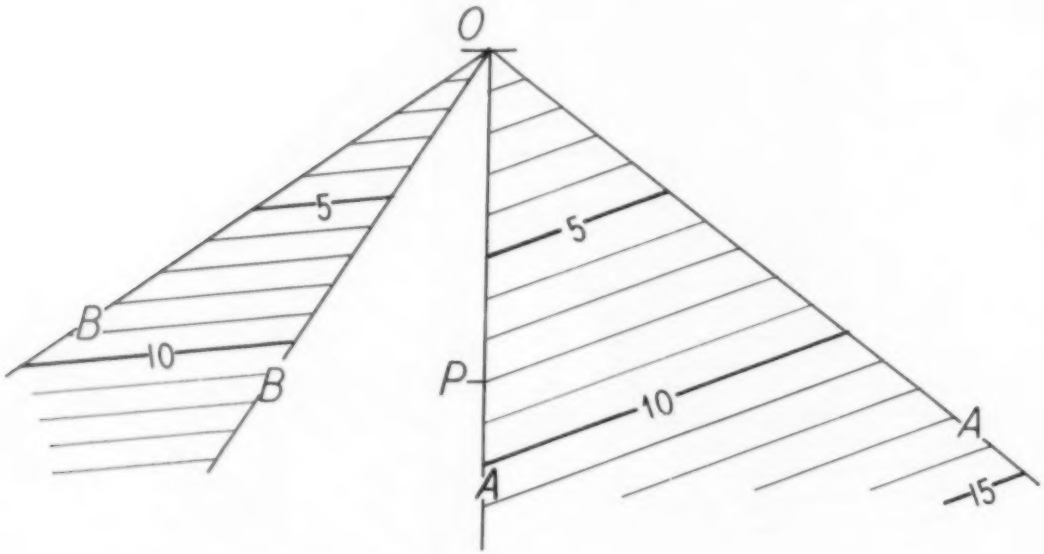


Figure 3l. S = 1.3.

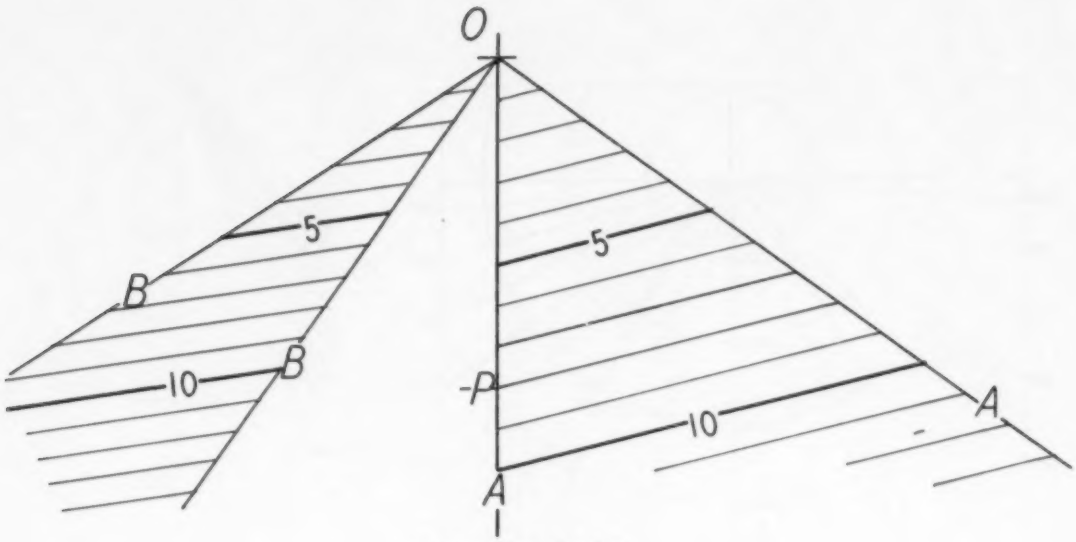


Figure 3m. S = 1.4.

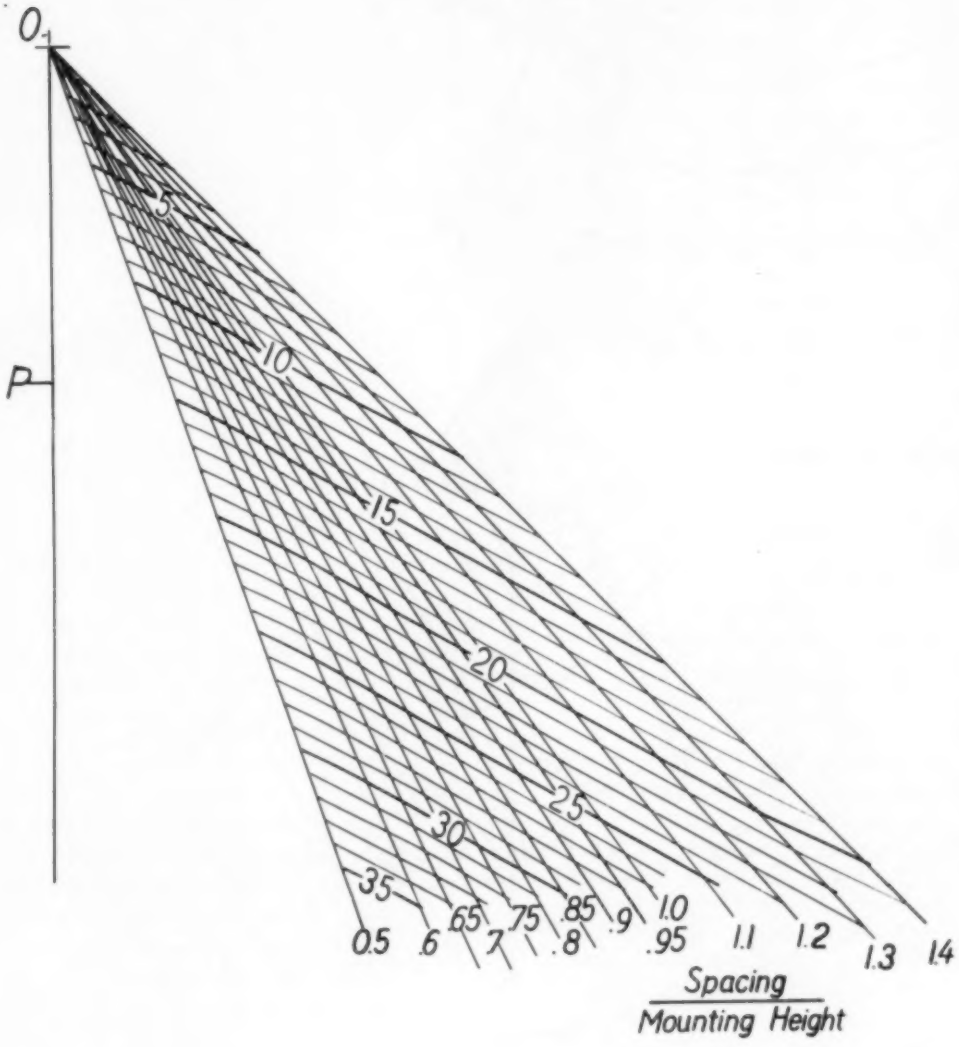


Figure 4.

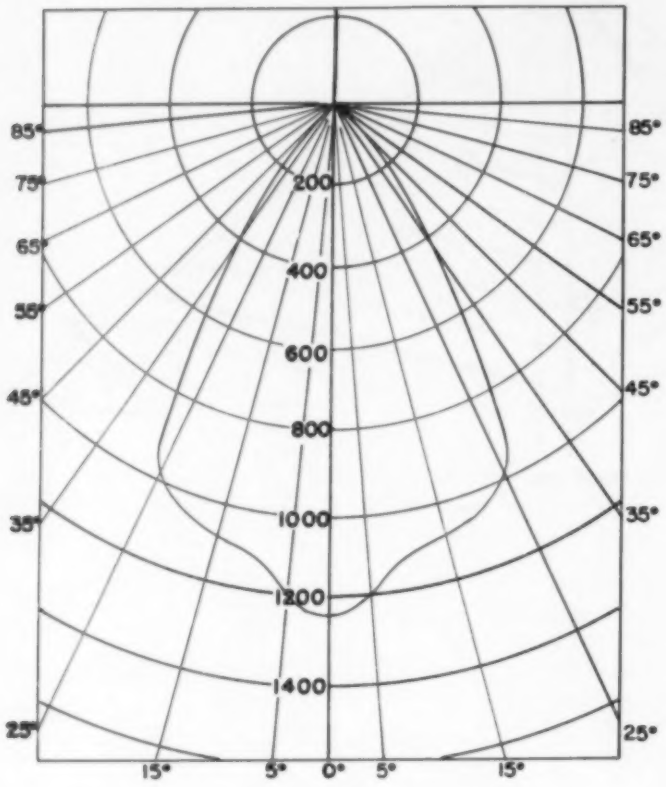


Figure 5.

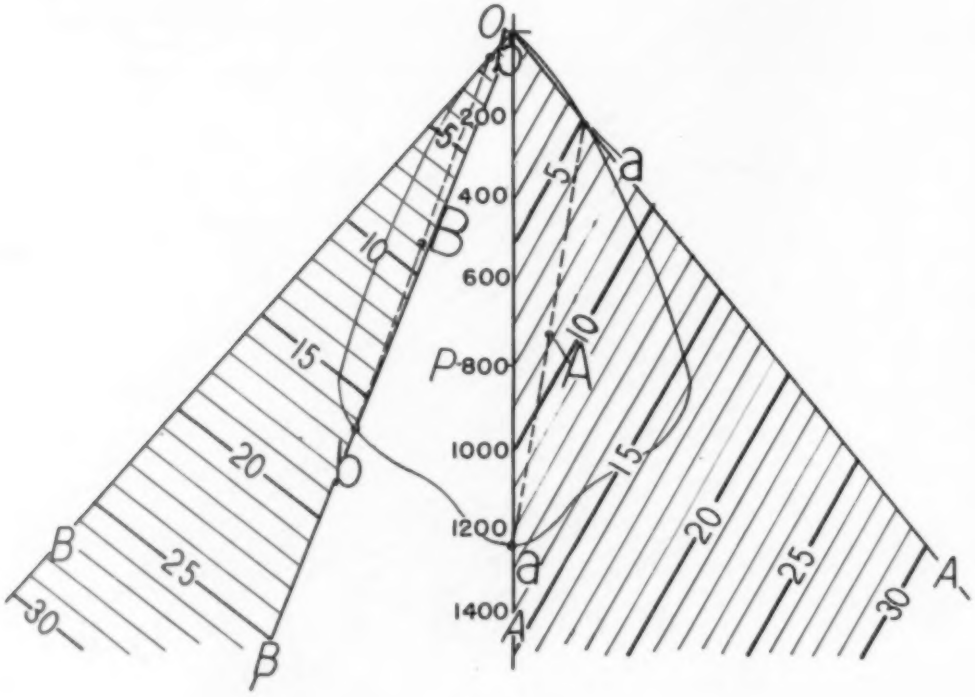


Figure 6.

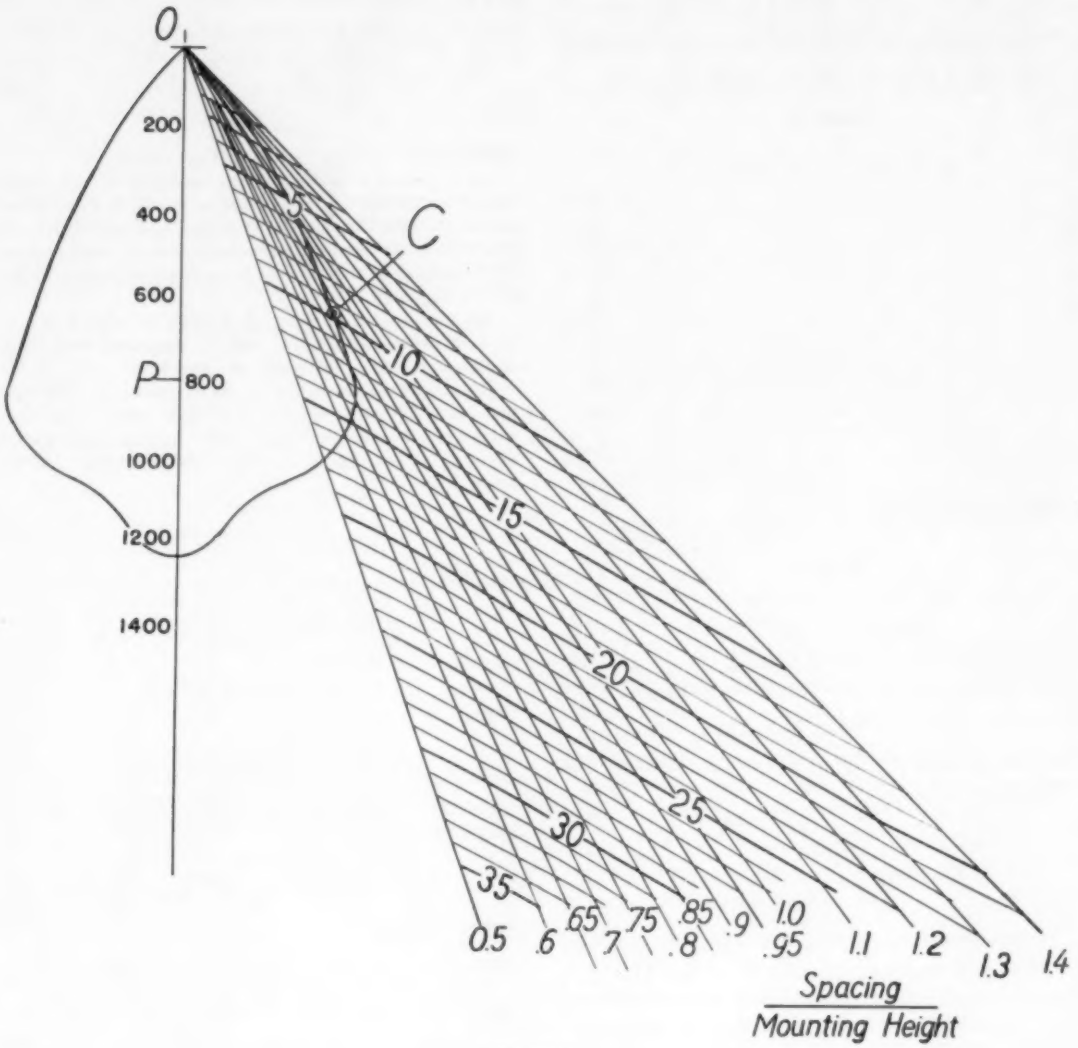


Figure 7.

preparation of these charts will be explained, enabling the reader to prepare charts better suited for his own particular purpose.

Charts for points A and B (Fig. 3): It will be noticed that all the charts of Fig. 3 include two straight lines OA and two straight lines OB inclined at certain angles and divided in equal segments of a certain length. Knowing the angles and sizes it is easy to draw these lines and to join, then, with straight parallel lines, the points of division, as shown in the different figures (Fig 3).

For square layouts, the following formulae give the inclination of the lines, for any value of s (ratio of spacing to mounting height):

$$\text{Angle } POA = \tan^{-1} s \qquad (4)$$

$$\text{Angle } POB = \tan^{-1} (\tfrac{1}{2} s) \qquad (5)$$

and the larger

$$\text{Angle } POB = \tan^{-1} (\tfrac{1}{2}\sqrt{5} \cdot s) \qquad (6)$$

The length of the divisions on the different straight lines, in inches, are:

$$OA \text{ (vertical)} = {}^1/_4 \text{ inch} \qquad (7)$$

$$OA \text{ (inclined)} = {}^1/_{16} (1+s^2)^{1.5} \qquad (8)$$

$$OB \text{ (inside)} = {}^1/_8 (1+{}^1/_4 s^2)^{1.5} \qquad (9)$$

$$OB \text{ (outside)} = {}^1/_{16} (1+{}^5/_4 s^2)^{1.5} \qquad (10)$$

Each chart so constructed will take into account all the light emitted by the luminaires below an angle of $\tan^{-1}\sqrt{2} \cdot s$. If corrective charts to include the light emitted up to an angle of $\tan^{-1} 2s$ (like Fig. 3a-c) have to be made, it will be necessary to know the slopes of the lines OB, OA and OC (Fig. 3a-c) as well as the lengths of the segments into which they are divided.

These angles are given by the following formulae:

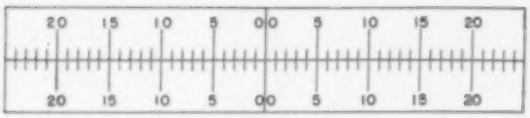


Figure 8.

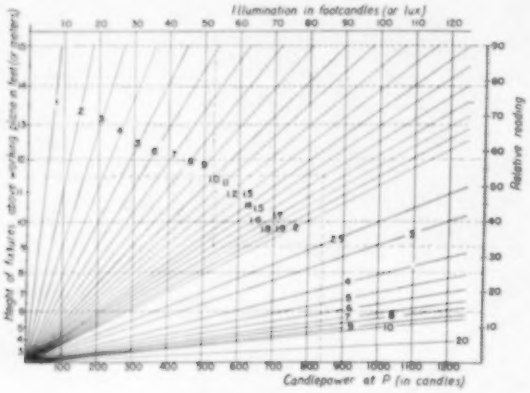

Illumination in footcandles (or lux)
Height of fixture above working plane in feet (or meters)
Relative reading
Candlepower at P (in candles)

Figure 9.

$$\text{Angle } POA = \tan^{-1}\sqrt{2}\cdot s \qquad (11)$$

$$\text{Small Angle } POB = \tan^{-1} 1.5s \qquad (12)$$

$$\text{Large Angle } POB = \tan^{-1} \tfrac{1}{2}\sqrt{13}\cdot s \qquad (13)$$

$$\text{Angle } POC = \tan^{-1} \tfrac{1}{2}\sqrt{10}\cdot s$$

and the lengths of the segments into which the lines are divided:

$$OA : {}^1/_8\,(1+2s^2)^{1.5} \qquad (14)$$

$$OB \text{ (inside)} : {}^1/_8\,(1+{}^9/_4 s^2)^{1.5} \qquad (15)$$

$$OB \text{ (outside)} : {}^1/_{16}\,(1+{}^{13}/_4 s^2)^{1.5} \qquad (16)$$

$$OC : {}^1/_{16}\,(1+{}^5/_2 s^2)^{1.5} \qquad (17)$$

If the corrective charts have to include the light emitted only up to an angle of $\tan^{-1}[\frac{1}{2}\sqrt{13}\cdot s]$, or, approximately $\tan^{-1} 1.80s$, they will consist of only three lines, as is shown in Fig. 3b-c. To construct such charts it will be necessary, again, to know the angles of these lines with the vertical and the lengths of their divisions. These angles are given by the following formulae:

$$\text{Angle } POA = \tan^{-1}\sqrt{2}\cdot s \qquad (18)$$

$$\text{Angle } POB = \tan^{-1} 1.5s \qquad (19)$$

$$\text{Angle } POC = \tan^{-1}(\tfrac{1}{2}\sqrt{10}s)$$

and the lengths of the divisions:

$$OA : {}^1/_8\,(1+2s^2)^{1.5} \qquad (20)$$

$$OB : {}^1/_4\,(1+{}^9/_4 s^2)^{1.5} \qquad (21)$$

$$OC : {}^1/_{16}\,(1+{}^5/_2 s^2)^{1.5} \qquad (22)$$

Appendix

Mathematical basis of the methods presented:

Let us assume a lighting layout consisting of many units located on the vertices of squares, as shown in Figs. 1 and 10 and that the illumination at points A, B and C is to be determined. As mentioned previously, all the light emitted by the fixtures at angles equal to or larger than $\tan^{-1}\sqrt{2}\cdot s$ will be neglected.

The illumination at point B, located, in plan, half way between two units (Fig. 1) will be considered first. This illumination will be the result of (Fig. 10):

(1) ***The illumination due to the two units 1:*** The light that reaches point B is emitted by these units at an angle α from the vertical; the candlepower at that angle will be called I_α. The illumination due to the two units 1, at the point B is:

$$E_{B1} = \frac{2I_\alpha}{H^2}\cos^3\alpha \qquad (23)$$

but (Fig. 10):

$$\tan\alpha = \frac{B'1}{H} = \frac{S}{2H} = \tfrac{1}{2}s \qquad (24)$$

so:

$$\cos\alpha = (1+\tfrac{1}{4}s^2)^{-\frac{1}{2}} \qquad (25)$$

and:

$$E_{B1} = \frac{2I_\alpha}{H^2}(1+\tfrac{1}{4}s^2)^{-1.5} \qquad (26)$$

(2) ***The illumination due to the four units 2*** will be, similarly:

$$E_{B2} = \frac{4I_\beta}{H^2}\cos^3\beta \qquad (27)$$

and as:

$$\tan\beta = \frac{B'2}{H} = \tfrac{1}{2}\frac{\sqrt{5}\cdot S}{H} = \tfrac{1}{2}\sqrt{5}\cdot s \qquad (28)$$

it is:

$$\cos\beta = (1+{}^5/_4 s^2)^{-\frac{1}{2}} \qquad (29)$$

and:

$$E_{B2} = \frac{4I_\beta}{H^2}(1+{}^5/_4 s^2)^{-1.5} \qquad (30)$$

(3) ***The light that reaches point B from the units 3*** is emitted at an angle α from the vertical:

$$\tan\alpha = \frac{B'3}{H} = \frac{1.5S}{H} = 1.5s > \sqrt{2}s \qquad (31)$$

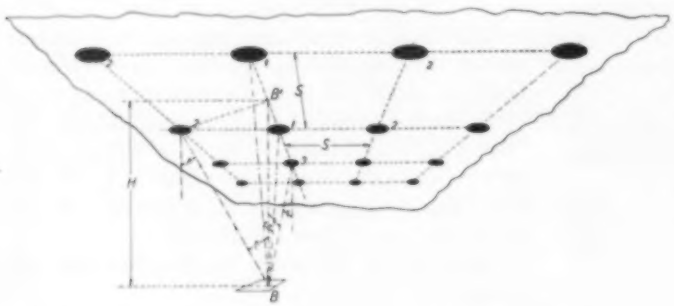


Figure 10.

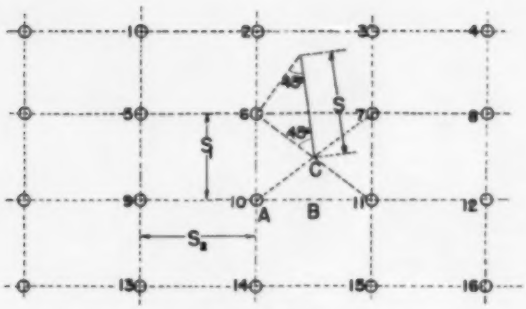


Figure 11.

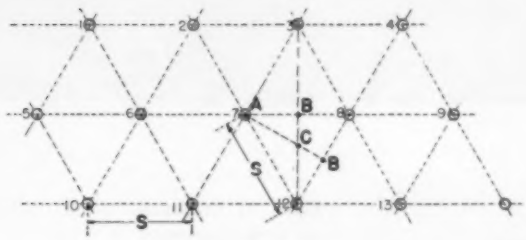


Figure 12.

i.e.:

$$\alpha > \tan^{-1} \sqrt{2} \cdot s$$

so that, as mentioned, this light plus all the light emitted by the units located still farther from B, will be neglected. The total illumination at B, can, therefore, be obtained by adding (26) and (30):

$$E_B = \frac{1}{H^2}[2I_\alpha(1+\tfrac{1}{4}s^2)^{-1.5} + 4I_\beta(1+\tfrac{5}{4}s^2)^{-1.5}] \quad (32)$$

Let it be assumed that a chart such as those of Fig. 3 is prepared, as was described in the second part of this paper. Comparing formulae (5) with (24) and (6) with (28) it can be seen that the angles POB of Figs. 3 are the same angles α and β of Fig. 10.

If the chart is laid under a candlepower distribution curve, the lines OB will intersect the curve (Fig. 6) at the points b, b.

As the candlepower reading at P is I_p, the lengths of the segments Ob will be:

$$\frac{OP}{I_p} I_\alpha \quad \text{and} \quad \frac{OP}{I_p} I_\beta \quad (33)$$

as these segments represent the candlepower at the angles α and β in the same scale in which OP represents I_p.

Since in all the charts (Figs. 3 and 4):

$$OP = 2 \text{ inches} \quad (34)$$

the lengths of the segments Ob will be, in inches:

$$\frac{2I_\alpha}{I_p} \quad \text{and} \quad \frac{2I_\beta}{I_p} \quad (35)$$

The lengths of the single divisions on the lines OB, are, in accordance with formulae (9) and (10):

$$\tfrac{1}{8}(1+\tfrac{1}{4}s^2)^{1.5} \quad \text{and} \quad {}^1/_{32}(1+{}^5/_4 s^2)^{1.5} \quad (36)$$

dividing (35) by (36), the readings at points $b\,b$ are obtained:

$$\frac{16I_\alpha}{I_p}(1+\tfrac{1}{4}s^2)^{-1.5} \quad \text{and} \quad \frac{32I_\beta}{I_p}(1+{}^5/_4 s^2)^{-1.5} \quad (37)$$

the reading R, half way between them will be the average of (37):

$$R = \frac{4}{I_p}[2I_\alpha(1+\tfrac{1}{4}s^2)^{-1.5} + 4I_\beta(1+{}^5/_4 s^2)^{-1.5}] \quad (38)$$

and multiplying both terms by $\frac{I_p}{4H^2}$:

$$\frac{I_p}{4H^2}R = \frac{1}{H^2}[2I_\alpha(1+\tfrac{1}{4}s^2)^{-1.5} + 4I_\beta(1+{}^5/_4 s^2)^{-1.5}] \quad (39)$$

which, compared with 32, gives:

$$E_B = \frac{I_p}{4H^2}R \quad (40)$$

identical to (1) which is, thus proved.

Therefore, the reading half way between the points $b\,b$ is proportional to the illumination at point B.

In a similar way it is possible to demonstrate that the illumination at points A and C is obtained as it was described, and that corrections to include the contribution of light emitted at higher angles can be obtained by supplementary charts such as those of Figs. 3a-c and 3b-c.

Applications to other types of layouts: Charts similar to the ones published and often the very same ones, can be used to obtain the illumination under other types of regular layouts.

The preparation of such charts (or use of published ones) for rectangular and triangular layouts is briefly explained. After becoming acquainted with the mathematical basis of these charts, similar ones for other situations will be easily developed.

Rectangular layout (Fig. 11): If S_1 and S_2 are the two spacings:

$$s_1 = \frac{S_1}{H} \quad (41)$$

$$s_2 = \frac{S_2}{H} \quad (42)$$

The illumination at points A and B can be obtained by means of charts prepared by a procedure similar to the one described for the preparation of the charts of Fig. 3. Such charts will take into account, for the point A, the contribution from units 6, 10 and 14 (Fig. 11) and for the point B, the contribution from units 6, 7, 10, 11, 14 and 15. A set of corrective charts (such as those of Fig. 3a-c) could take into account the contribution from units 5, 7, 9, 11, 13 and 15 to point A and from 2, 3, 9, 12, etc. to point B.

The illumination at point C, instead, can be obtained directly with the charts published, exactly as it was explained and using a value of s determined by the following formula:

$$s = \sqrt{\tfrac{1}{2}(s_1^2 + s_2^2)} \quad (43)$$

or by:

$$s = \frac{S}{H} \quad (44)$$

where S is determined graphically as shown in Fig. 11.

Triangular layout (Fig. 12): The illumination at A and B can be obtained from charts similar to those shown in Fig. 3, which will take into account, for the point A, the contribution of units 2, 3, 6, 7, 8, 11 and 12 and, for point B, 3, 7, 8 and 12.

The illumination at point C will be exactly ¾ of the value obtained by the use of the charts published (Fig. 4) for

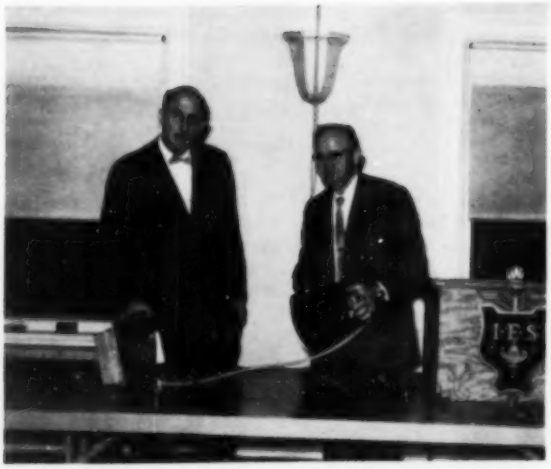
$$s = \sqrt{\tfrac{2}{3}} \cdot \frac{S}{H} \cong 0.8165 \frac{S}{H} \quad (45)$$

Here and There With I.E.S. Members

IES General Secretary R. G. Slauer, second from left, spoke at the February meeting of the Eastern Pennsylvania Section on "Lighting Highlights of 1959." Talking with Mr. Slauer after his speech are, left to right, R. J. Pretzman, Chairman; (Mr. Slauer); R. A. Reynolds, Secretary-Treasurer; H. F. Carroll and Joseph Freeman. Eighty-two attended the meeting, held in Harrisburg, Pa.

Fifteen Past Chairmen of the Golden Gate Section honored at a recent Section meeting were: Front row, left to right: C. W. Macy, 1957; Guy de Leuze, 1956; Harold Wright, 1955; James Barnes, 1954; Sol Cohn, 1950; D. M. Finch, 1949; H. H. Robison, 1947. Middle row: John Walsh, 1942; Robert Dummel, 1938; Romaine Myers, 1943; Gilbert Trosper, 1936; Harold Gerber, 1933; W. A. Cyr, 1945. Back row: Carl Martin, 1929; James Cravath, 1924, and Charter Member of IES, hidden behind Gerber. Pins were presented to the Chairmen by the grateful Section.

Milwaukee Section's February meeting featured Robert E. Frank, Wakefield Co., at left in photo at left, speaking on "High Frequency Applications." Shown here with Mr. Frank is Section Chairman Marshall H. Bruesewitz.



At left in photo at right is R. A. Schaffer, Study Club Chairman, shown introducing A. B. Rowold, A. B. Rowold Co., speaker at the Study Club meeting. Mr. Rowold discussed aspects of "Vertical Surface Illumination."

LIGHTING NEWS

New Residence Lighting Forums In K. C. and S. F.

Swelling the total to 12, two new Residence Lighting Forums of IES are now operating successfully, in Kansas City and San Francisco, the latter sponsored by the Golden Gate Section. Chairman of the Kansas City Forum, which held its Charter meeting February 3, is Frank I. Feagans, Residential Lighting Consultant for the Kansas City Power & Light Co. L. A. Russell, Prescolite Manufacturing Co., Berkeley, Calif., is Chairman of the new San Francisco Forum. Five additional Residence Lighting Forums are nearing formation. These: Oklahoma City, Okla.; San Jose, Calif.; Binghamton, N. Y.; Springfield, Ill. and San Antonio, Texas.

In addition to the phenomenal growth in this activity, all of the Residence Lighting Forums (see list below) have been chalking up enviable attendance records, ranging from 50 to 125 present at every meeting (eight per year, same as Sections). A wide variety of programs on the subject of home lighting and decoration have been offered at these meetings. Some of the most successful subjects have been:

Christmas Lighting Idea Exchange
Meeting with Residential Lighting Fixture Distributors
Panel Discussions
Home Lighting Trends — Indoors and Out
Tours of Well-lighted Homes
What's New in Light Sources
Professional Approach to Lighting
Garden Lighting Tours and Talks

The Forums have also been influential in promoting Class I entries for local MMILJ contests and bid fair to outshine Class II in the number competing.

IES Residence Lighting Forums currently flourishing are located at:

Atlanta, Ga.	New York, N. Y.
Chicago, Ill.	Phoenix, Ariz.
Dallas, Texas	St. Louis, Mo.
Detroit, Mich.	San Francisco, Calif.
Kansas City, Mo.	Salt Lake City, Utah
Minneapolis, Minn.	Washington, D. C.

A brochure describing the activities of Residence Lighting Forums, titled "Why IES Residence Lighting Forums?" may be obtained from Miss Virginia Skinner, Chairman of the Residence Lighting Forums Committee of IES. Her address is Long Island Lighting Co., 175 Old Country Road, Hicksville, L. I., N. Y.

Permanent Lamp Parts Center To Be Established in New York

A permanent exhibition center for parts, materials and supplies used in the construction of lamps and luminaires will open on June 1 in New York City, according to an announcement by H. Newman Clark, Executive Director of Product Designer Displaycase. The center will be located at One Park Avenue, adjacent to the New York Furniture Exchange.

The objective of the exhibition center is to provide a complete clearinghouse for every product and idea used in the design and construction of lamps and luminaires where designers and manufacturers of lighting products can observe and compare all available parts and supplies and obtain complete information and specifications on materials of interest to them. In addition to the displays of new products, the center will also publish a monthly newsletter concerned with the latest developments in components and their application.

Exhibits are already being designed and all designers and manufacturers who are interested in participating in the "Displaycase" may obtain further information from Mr. Clark, at the abovementioned address.

Similar display centers are being planned for the South, Midwest and Pacific Coast.

San Jose Chapter Co-Sponsors Industrial Vision Conference

A full-day Conference on Industrial Vision and Illumination was held on Friday, March 5, at the Sainte Claire Hotel, San Jose, Calif. The Conference was a joint undertaking of the San Jose Chapter of IES, the Santa Clara County Optometric Society and the Electrical Construction Industry Advisory Committee.

Valuable lectures and workshops de-

(Continued on page 10A)

OFFICERS of the newly-organized Heart of America Residence Lighting Forum are, left to right, Reuben Sell, Member-at-Large; Kathleen Ricketts, Secretary; R. W. Wilson, Vice-Chairman; Frank I. Feagans, Chairman. Other officers not shown are Robert Battle, Treasurer and M. A. McElroy, Member-at-Large. More than 40 people attended the organizational meeting of the Forum.

(Continued from page 9A)

signed to show practical ways to increase profits, step-up production and insure greater worker efficiency comprised the major portion of the Conference program. In addition, there were manufacturers' displays of the latest lighting equipment.

Program was as follows:

Morning Session

Moderator — George Harter, National Electrical Contractors Association, Santa Clara-San Benito Counties Chapter.

How Visual Efficiency Affects Your Plant — Dr. John Babcock, California Optometric Association Industrial Vision Committee, Redwood City, Calif.

How Proper Lighting Affects Your Plant — Stephen Lindheim, Schwartz & Lindheim, Oakland, Calif.

Exhibits of Lighting Equipment.

Afternoon Session

Workshop No. 1 — Increased Profits through Illumination and Improved Vision — Panel: F. E. Duhme, Jr., Smoot-Holman Co., San Francisco, Calif.; Dr. David Green, President, Central Coast Optometric Society, Hollister, Calif.

Workshop No. 2 — Proper Lighting and Vision — Tools for the Job — Panel: Dr. Charles F. Pearson, State Director of Postgraduate Optometric Education for California Optometric Association, Carmel, Calif.; E. P. Homer, General Electric Co., Lamp Division, Oakland, Calif.

Workshop No. 3 — What To Look for in Your Plant — Panel: Robert Thunen, Sylvania Electric Products, Inc., Burlingame, Calif.; Dr. Donald Jaques, California Vision Conservation Institute, Monterey, Calif.

Certified Lighting Course Offered to California Contractors

Realizing the need for acquainting electrical contractors with good lighting principles, the Certified Lighting Association, sponsored by the lighting industry of Southern California, in cooperation with the Electrical League of Los Angeles, is conducting a course in lighting design and sales promotion, designed specifically for electrical contractors.

Lectures began on April 7, and will run for seven weeks. Nine dollars covers the costs of the weekly two-hour lectures and the student manual.

Roy H. Kreyser, Department of Water and Power, City of Los Angeles, is Coordinating Director for the course, which features:

April 7 — Don't Cut Holes in Your Own Pocket—R. H. Crockfield, Los Angeles Sales Executive Club; Seeing to Sell — S. M. Johns, Electric Corp. of California; The Language of Lighting — R. F. Bevan, Sylvania Electric Products, Inc.

April 14 — Lamps and the Job They Do — J. Roy Jones, Westinghouse Electric Corp.; Ballasts — James Grant, General Electric Co., Apparatus Division.

April 21 — Basic Lighting Design — Edward Balogh, Sunbeam Lighting Co.

April 28 — Lighting Design for Merchandising — D. A. Romanoff, Lighting Dynamics, Inc.; How to Sell Lighting for Merchandising — J. Silvers, Globe Illumination Co.

May 5 — Lighting Design for Offices — Edward Balogh, Sunbeam Lighting Co.; How to Sell Office Lighting — R. L. Ford, Columbia Lighting.

May 12 — Lighting Design for Industrial Interiors — Bill F. Jones, Smoot-Holman Co.; How to Sell Industrial Lighting — Robert Clubley, General Electric Co.

May 19 — Floodlighting Calculations — W. R. McMillan, Westinghouse Electric Corp.; Floodlighting Applications — "Buck" Clubley, Smoot-Holman Co.; L. A. Hobbs, Los Angeles Electric League.

Certificates will be awarded to those who successfully complete the course.

SPEAKERS at the New Jersey Section's School Lighting Clinic included, from left to right, R. L. Zahour, Chairman, New Jersey Section; Harvey Winter, Consulting Engineer; Professor E. M. Strong, Cornell University; Dr. C. O. Westby, Director of School Building Service, State of New Jersey and Dr. H. A. Hollingsworth, Superintendent of Bloomfield Schools.

New Jersey Section School Lighting Clinic

A comprehensive school lighting clinic featuring three prominent New Jersey educators, two electrical engineers, an architect and several IES members was sponsored by the New Jersey Section on February 19. The clinic, which was held in the Bloomfield High School Auditorium, Bloomfield, N. J., was divided into two sessions — afternoon and evening — with a tour of the school building and dinner between the technical sessions.

The high school tour was of particular interest, in that it presented a complete history of school lighting in actual use—from the early low level incandescent equipment to the more efficient sources and better fixtures used today.

Program for the clinic was:

Afternoon Session

Welcome — George B. Well, President, Bloomfield Board of Education.

History of School Lighting Practice — R. L. Zahour, Chairman, New Jersey Section, IES.

Economics of Lighting New Schools and Relighting Old Ones — Raymond Nutall, Assistant Superintendent of School Business, South Orange and Maplewood School District.

Question and Answer Period — Moderator, H. L. Sykes, Chairman, School Lighting Clinic.

Tour of Bloomfield High School.

Evening Session

Resume of Afternoon Session — H. L. Sykes.

An Educator's View of the Importance of School Lighting — Dr. H. A. Hollingsworth, Superintendent of Bloomfield Schools.

School Lighting for Comfort and Efficiency — Dr. C. O. Westby, Director of School Building Service, Department of Education, State of New Jersey.

Confusion, Comfort and Cost in School Lighting — Robert Micklewright, Micklewright and Montford, Architects.

A Consulting Engineer's View of the Problem of School Lighting — Harvey Winter, Vogelbach and Baumann, Consulting Engineers.

Oh, Say Can You See? — Everett M. Strong, Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.

Question and Answer Period — H. L. Sykes.

Yankee Chapter Meets With U of Mass. Students

The first project in the Yankee Chapter's local "lighting education" program resulted in a very successful joint dinner meeting of the Chapter and the Student Branches of AIEE and IRE at the University of Massachusetts, Amherst.

Lawrence Cooke, General Electric District Engineer, was the featured speaker at the dinner and his talk on "Illuminating Engineering — Past, Present and Future" did much to stimulate student interest in lighting and the illumination profession. During dinner, each IES member sat with two or three students whom he "sponsored" and answered any

(Continued on page 13A)

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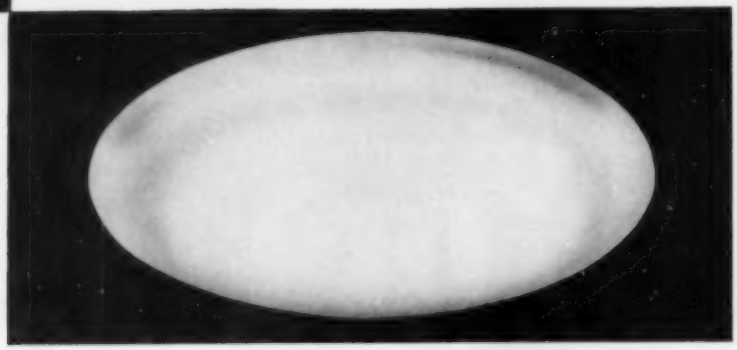

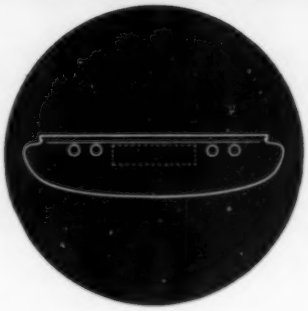

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HAWAII
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(*Continued from page* 10A)

questions the young men had about illuminating engineering.

The meeting was arranged by Arthur Brodeur, Jr., Yankee Chapter Program Chairman and Richard Martel, Chairman of the AIEE Student Chapter.

Future "education" programs for other local groups are being planned.

Outdoor Projections In Daylight Demonstrated

What may be the forerunner of daytime drive-ins was demonstrated recently on the roof of an Argentine school (see cut). This was the successful demonstration of film projection in broad daylight, with ordinary projectors, without any reduction of visibility.

The answer is the screen itself, an invention of Isaac Goodbar, New York City illuminating engineer (patent pending). In this, a system of black cells does not affect the light reaching the screen from the projector but attenuates heavily any light coming from the rest of the environment. The screen shown has an attenuation of 314. *i.e.*, images are seen as they would be on a screen of the same size in an environment-brightness 314 times smaller. Any other attenuation desired, however, can be obtained. Models up to 17 feet wide have been tried. The screen, the projector and all the space between them are in the open.

In the model shown, projection is from the rear, although further developments have made front projection possible.

Expected applications of this development will probably be for rear projection in outdoor advertising, audio-visual education, etc., for front projection, drive-in theatres, and schools.

SCREEN for outdoor projection in broad daylight. In this model, projection is from the rear.

SCHEDULED EVENTS

April 22, 1959—Council Executive Committee Meeting, Illuminating Engineering Society, Grove Park Inn, Asheville, N. C.

April 22-24, 1959—South Central and Southeastern Regional Conference, Grove Park Inn, Asheville, N. C.

April 27-29, 1959 — National Association of Lighting Maintenance Contractors, Annual Convention, Cosmopolitan Hotel, Denver, Colo.

May 3-8, 1959 — Society of Motion Picture and Television Engineers, The Fontainbleau, Miami Beach, Fla.

May 4-5, 1959 — Southwestern Regional Conference, Shamrock-Hilton Hotel, Houston, Tex.

May 6-8, 1959 — Midwestern Regional Conference, Pere Marquette Hotel, Peoria, Ill.

May 6-8, 1959 — Electrical Manufacturers Representatives Association of Michigan (1959 Electrical Exhibit), Detroit Artillery Armory, Detroit, Mich.

May 11-12, 1959 — Inter-Mountain Regional Conference, Continental Hotel, Denver, Colo.

May 20-21, 1959 — Building Research Institute Conference on Building Illumination, Statler-Hilton Hotel, Cleveland, Ohio.

May 24-29, 1959 — National Association of Electrical Distributors (51st Annual Convention), Conrad Hilton Hotel, Chicago, Ill.

May 26-30, 1959 — Pacific Northwest Regional Conference, Banff Springs Hotel, Banff, Alta.

June 4-5, 1959 — Northeastern Regional Conference, Curtis Hotel, Lenox, Mass.

June 11-12, 1959 — Canadian Regional Conference, Chateau Laurier, Ottawa, Ont.

June 18, 1959 — Council Meeting, Illuminating Engineering Society, New York, N. Y. Members are free to attend meetings of Council as guests.

June 22-23, 1959 — Great Lakes Regional Conference, Lafayette Hotel, Buffalo, N. Y.

June 22-26, 1959 — American Institute of Electrical Engineers, Summer and Pacific General Meeting, Seattle, Wash.

September 7-11, 1959 — National Technical Conference of the Illuminating Engineering Society, Hotels Fairmount and Mark Hopkins, San Francisco, Calif.

October 5-10, 1959 — Society of Motion Picture and Television Engineers, Hotel Statler, New York, N. Y.

October 12-14, 1959 — National Electronics Conference, Inc., Hotel Sherman, Chicago, Ill.

October 12-16, 1959 — American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 19-20, 1959 — Annual Meeting of the United States National Committee (C.I.E.), Nittany Lion Inn, State College, Pa.

November 2-5, 1959 — Eleventh Exposition of the Air-Conditioning and Refrigeration Industry, Convention Hall, Atlantic City, N. J.

November 9-13, 1959 — National Electrical Manufacturers Association, Traymore Hotel, Atlantic City, N. J.

Soviet Scientific Translation Service Reported to be World's Largest

The Soviet Institute of Information, a centralized agency for the translation and dissemination of scientific and technical information is the most efficient and comprehensive organization of this type in the world, according to a report given by R. K. Honaman, Director of Publications, Bell Telephone Laboratories, at the Winter General Meeting of the American Institute of Electrical Engineers. Half of the world's technical information is made available to Soviet scientists and engineers through the vast activities of this Institute which analyzes about 14,000 pieces of technical literature each year.

Although President Eisenhower has directed the National Science Foundation to organize a coordinating agency for dealing with scientific information in the United States, at the present time no similar service is available to American scientists and engineers. As a result, according to Mr. Honaman, there is much duplication of foreign translations in this country and much valuable information remains unpublished.

Post-Conference Hawaiian Tours May Launch New IES Chapter

The new state of Hawaii may have been "blacked out" during World War II, but as if to compensate for the wartime darkness, the use of light on the Hawaiian Islands today is very lavish in commercial and industrial areas, and particularly in homes. Due to the efforts of many IES members on the Islands, lighting knowledge has advanced more rapidly there than in many communities of comparable size on the mainland.

It is with this background that James Barnes, South Pacific Coast Regional Vice-President hopes that the Hawaiian tours planned for IES'ers following the

(*Continued on page* 14A)

(Continued from page 13A)

San Francisco Conference, September 7-11, may provide the impetus for the formation of a chapter in Hawaii. The interest of IES members on the Islands has been aroused and plans are being made for a meeting of those eager to form a chapter. It is thought that if a considerable number of the delegates to the Conference take the Hawaiian tour (see March IE, p. 9A for details), a program can be developed to present to the Hawaiians as a stimulus for the formation of a new chapter.

According to tentative plans, the meeting would be held at the Royal Hawaiian Hotel on Wednesday, September 16, following a special dinner in the Coconut Grove lanai.

Slide Library Available For Residence Lighting Forums

Program Chairmen of the 12 active IES Residence Lighting Forums throughout the country will have available to them this coming year, a library of prize-winning home lighting installations, including text and colored slides. Winners of last year's Class I MMILJ entries are being duplicated for use on RLF programs. Individual Forums may apply for these (well in advance of their meeting is suggested) to John Michel, IES Headquarters, 1860 Broadway, New York 23.

From the Desk of the President

In the formation of any organization, one of the first steps is selection of a leader, be he called President, Chairman, or whatever. Usually, the man who has taken the lead in forming the group is chosen, or elected. The next officer chosen is the Secretary. Upon the Secretary, falls the responsibility of setting up and maintaining both the membership and the financial records, as well as executing the procedures adopted by the organization for its operation. The Secretary, therefore, may well be considered the keystone in the orderly management of an organization.

Our Society has long recognized this and mentions frequently in its By-laws and Procedures, the various duties and services of the Secretary.

Soon after the founding of our Society in 1906, it was recognized that the elected General Secretary could not handle, on a voluntary basis, all of the assignments. The Society, therefore, authorized "one or more Headquarters staff members to assist him."

The growth of the Society has been such that currently the General Secretary has some nine assistants directly serving the administration and handling the Society's records. (In addition, thirteen staff members carry out the services to the Publications and Technical programs of the Society.)

The group which assists the General Secretary directly, is headed by John Michel, appointed as Office Manager last Fall. In this position he has taken over many duties previously performed by the Executive Secretary. A view of his work, and the services of his staff, can be seen from the following highlights of some of the services performed in the "General Secretary's office" at Headquarters.

Membership Records

The steady increase in Society membership necessitates a proportionate increase in membership record work. In addition to active membership records, losses due to resignations, non-payment of dues, and death, involve correction of all Headquarters files as well as reporting these changes to the Sections and Chapters. A vast number of address changes also require similar correction of all Headquarters files, Section and Chapter notification, and correction of the Society mailing list.

New Members

With the exception of the few members reinstated after resignation, all elections involve the processing of application forms. This includes checking — for past membership record, for completion, for required references (especially in Member grade elections) and for approval by the local Board of Examiners. At Headquarters, Mrs. Nellie Tono, assisted by Miss Lisa Goldmaier, now processes all applications in preparation for the General Board of Examiners and prepares the various file cards and file folders.

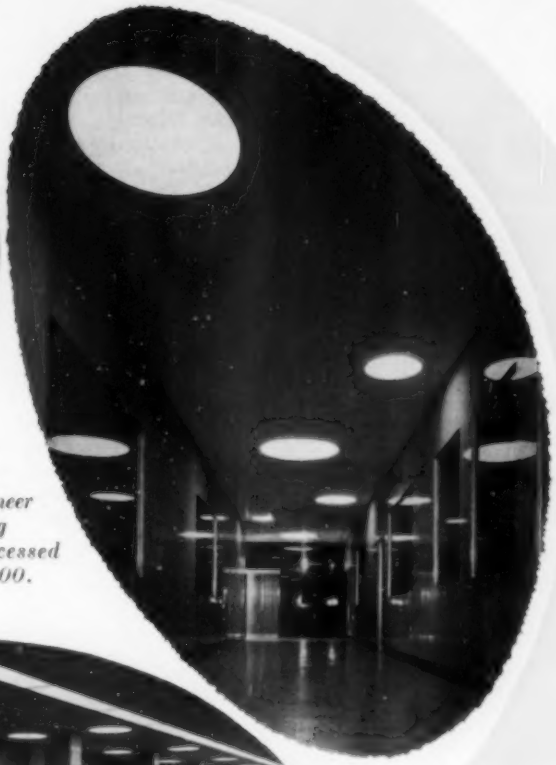
Members — Financial Records

An individual financial account for each member is set up at Headquarters. Each member is billed annually for dues. All dues invoices are entered on the books, and each cash receipt is individually recorded.

Since the Society is a non-profit organization, it is characteristic that the Council annually budgets expenses that are calculated to consume all of the Society's income for the year. The "balanced budget" situation makes the Council especially sensitive to the month-by-month financial condition of the Society. The continual struggle to keep up with the natural concern of the Council and of the Finance Committee, and to supply the financial statistics for periodic re-

(Continued on page 16A)

KAIMANAHILA, the "Lighting for Living" home in Honolulu's Fall 1958 Parade of Homes represented the well-lighted home and garden. Illumination features included kitchen counter lighting, luminous ceiling in the sewing room, and extensive use of cove lighting in living and dining areas. Carefully planned garden lighting used underwater lamps in pool and other concealed sources. A number of outdoor receptacles, planned in advance, permits changing of lighting arrangements. House designed by Architect, K. Onodera.



Excitingly new lighting possibilities are open to the architect, engineer and contractor with Sunbeam Lighting Company's circular recessed Visionaire® Series #CSP3800.

DECORATIVE CONTRASTS ARE YOURS WITH CIRCULAR VISIONAIRES®

From Massachusetts to California you can see many installations of these contemporary circular Sunbeam Lighting Company Visionaires. Dramatic effects are obtainable by installing these units in various sizes in random patterns. Nominal 2-ft, 3-ft and 4-ft diameters, the CSP3800 Series, as "large area" sources, produce high level, low brightness illumination. They take standard fluorescent lamps. The domed translucent white Plexiglas diffuser opening on concealed hinges, has long-life characteristics assuring minimum maintenance. The smart, circular trim fits flush to the ceiling and the recessed enclosure is square in shape permitting standard installation methods. Write today for bulletin #DS1.

SUNBEAM LIGHTING COMPANY
777 East 14th Pl., Los Angeles 21, Calif.
3840 Georgia St., Gary, Ind.

(Continued from page 14A)

ports, is eased by the effective control exercised by Miss Florence Tuebner, bookkeeper, and her assistant Mrs. Lucille Ardizzone.

Membership Committee Campaign

As a standard monthly operation, Headquarters has continued the charting of the membership campaign resulting from the monthly report of the Board of Examiners. The significant changes in the Section and Chapter positions are reported to the National Membership Chairman. He in turn incorporates these in his monthly campaign letter, which together with the tabulations go to the officers of all Sections and Chapters, Membership Chairmen, as well as to the National Council and the Executive Committee. The preparation and duplication of this mailing as well as numerous other monthly mailings are handled by Mrs. Terry Elbe and Mr. Tom Carrod at Headquarters.

The Society thrives on members, however. It is very important that dues be paid promptly and delinquency be avoided so that efforts expended on delinquent member accounts can be utilized for more productive activity. The active participation of all members in obtaining members and keeping present members is vital to the continued growth of the Society.

National Board of Nominations

It is an annual task of Headquarters to assist in the formation of the National Board of Nomination and in the organization of its work. There has been developed for this purpose, an operating schedule as a guide for the various steps. Apart from the communication to Sections to secure their national and local representatives, Headquarters has duplicated a considerable file of information on past officers and national committee Chairmen of the Society. Following the report of the National Board of Nomination, the Regional Nominating Committees and the Section Nominating Committees, the election ballot is prepared. The printing and mailing of the election ballot is done on a "tight" schedule, but nevertheless is on schedule every year.

Probably the best word to summarize or describe the function of this Headquarters group is "service"; service to the membership; to the Council; to many Committees, and a close association with the General Secretary on the general operations of the Society.

GEORGE J. TAYLOR,
IES President, 1958-1959.

MEMBERS of the Southern California Section touring the UCLA Engineering Buildings during their February meeting at the University. Professor Philip F. O'Brien (third from right with back to camera) conducted the tour. The building at left, located on the roof of the Engineering Building, is a facsimile of a room. Every electrical engineering student is required to make lighting measurements of the daylight of the room and compute the "flux transfer" into the room interior. Results are checked with the analogue computer (visible inside the room) and with a digital computer located in another part of the building.

ABOUT PEOPLE

John C. Virden Co., Cleveland, Ohio, recently acquired the Lighting Dynamics Division of Ekco Products Co., Chicago, Ill., according to a joint announcement made by **Arthur Keating,** Chairman of the Board of Ekco and **John C. Virden, Jr.,** President of Virden. Lighting Dynamics will be operated as a subsidiary of the Virden Co. In other developments, Virden has named **Vernon L. Wrye,** former assistant to the vice-president in charge of marketing, as sales manager for the firm's lighting division; **Matthew E. Nesta** as plant manager of the two Cleveland plants and **Fred H. Alexander** as sales representative for the states of Louisiana, Mississippi and Arkansas.

George A. Nagel, Consulting Engineer, Chester, Conn., has been retained by Donald Deskey Associates, Industrial Designers, New York, N. Y., as electrical consultant in the "Street Lighting Development Program" which Deskey is preparing for the City of New York.

Amalgamated Electric Corp., Ltd., Toronto, Ont., has announced the appointment of **W. A. Dalrymple** as sales manager — lighting. Mr. Dalrymple, Chairman of the IES Public Relations and Information Committee and lighting representative of CEMA Market Development Council has served in various capacities with the company, including manager of the wiring supplies and lighting departments.

Henry G. Booker, professor of electrical engineering at Cornell University, Ithaca, N. Y., has been named director of the University's School of Electrical Engineering. Professor Booker joined the Cornell faculty in 1948 after having taught at the University of Cambridge in England.

Under a reorganization of the Department of Water and Power, City of Los Angeles, Calif., **Roy H. Kreyser** was advanced to the position of illuminating engineer, sales promotion, and **T. H. Shepherd** was promoted to sales promotion and planning supervisor, general sales division.

Robert W. Erskine has been named sales supervisor in Portland, Ore. for Sylvania Lighting Products, division of Sylvania Electric Products, Inc., according to an announcement by **Garlan Morse,** V-P in charge of sales. Mr.

(Continued on page 18A)

Up to 163 Degree Spread — Up to 236,000 Candlepower: Now in

New CROUSE-HINDS Mercury Floodlights

Plus 6 Outstanding Advantages Never Before Offered in Mercury Floodlights of this Wattage

New—700 to 1,000 watt mercury floodlights with the widest beam-spread on the market . . . up to 163°. Or the brightest . . . 236,000 candlepower concentrated in a 75° solid angle! Complete with ballasted assemblies that will start lamps at −30° F. offering a further choice of three different reflectors and four different lenses (including a spun-sealed plate glass lens) to adjust the beam-spreads and candlepowers to your particular needs. All using either clear lamps for brightness, or phosphor-coated lamps for color enhancement. And all offering rear-door relamping and positive locking in open position.

Mercury Floodlighting Is Here to Stay

No other floodlight lamp approaches mercury for long burning hours . . . for economy of cost and labor in relamping. And no other mercury floodlight approaches these new MVF's for convenience of relamping, aiming, utilization factor and maintenance of output over a long period of burning. Other lights in the Crouse-Hinds range of floodlights from 250 to 700 watts provide varying beam spreads, intensities and efficiencies.

✱ For assistance in computing the exact fixtures, wattages and footcandles for your needs, consult your Crouse-Hinds distributor or the Illumination Department at the Factory.

CROUSE HINDS

MAIN OFFICE AND FACTORY: SYRACUSE, NEW YORK
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.
Crouse-Hinds Instrument Company, Inc., Silver Spring, Maryland

● CONDULET® ELECTRICAL EQUIPMENT (Explosion-Proof and Conventional) ● FLOODLIGHTING
● TRAFFIC CONTROL SYSTEMS ● AIRPORT LIGHTING and WEATHER MEASURING EQUIPMENT ●

These products are sold exclusively through electrical distributors. For application engineering help, contact one of the following offices: Atlanta Baton Rouge Birmingham Boston Buffalo Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul Salt Lake City San Francisco Seattle Tulsa Washington **Resident Representatives:** Albany Baltimore Charlotte Chattanooga Reading, Pa. Richmond, Va.

Harold Wright (at rostrum), Past Chairman of the Golden Gate Section addressed the Electric Club of San Francisco on the aims and projects of IES. Mr. Wright's talk was part of the club's program in observance of National Electrical Week. C. W. Leihy, Electric Club President, is shown here with Mr. Wright.

(Continued from page 16A)

Erskine joined the company in 1953 as Salt Lake City field representative. Also announced by Mr. Morse was the promotion of **C. H. Connely,** former senior salesman in the Los Angeles area, to the position of Denver district sales manager.

In connection with the reorganization of its Lake States and Allegheny sales districts, the Union Metal Manufacturing Co., Canton, Ohio has announced the following changes. **W. B. Vick,** former manager of the Lake States District was named special representative to work with state and municipal governments in the area. **C. F. Clark,** Mr. Vick's assistant since 1950, takes over as manager of the district which includes western Ohio, the lower peninsula of Michigan and Kentucky. The Allegheny District which formerly included West Virginia, western Pennsylvania and western New York has been expanded to include the eastern half of Ohio. **M. J. Vitartas** continues as district manager. Headquarters of both districts will remain in Canton.

Stephen DeCoste has been named supervisor of sales of plugs, receptacles and connectors for the Crouse-Hinds Co., Syracuse, N. Y. Mr. DeCoste will have his office at the company's Syracuse headquarters.

Jefferson Electric Co., Bellwood, Ill. has announced the appointment of **Dale Campbell** as advertising director. Prior to this appointment, Mr. Campbell had been associated with the Operating Department of the R. R. Donnelley and Sons Co.

Eugene W. Commery, who retired last October as supervisor of residential lighting applications for the General Electric Co., Cleveland, Ohio, is now working as a lighting design and color consultant from his retirement headquarters in Key Biscayne, Fla.

Kirlin Co., Detroit, Mich., has announced the appointment of **W. J. Childers** of Dallas and **Robert A. Putterman** of Houston as their sales representatives for the state of Texas with the exception of the area surrounding El Paso and a small northeast portion of the state.

Jones-Philibert & Co. have been named as sales representatives for Louisiana, Mississippi and western Tennessee by the Edwin F. Guth Co., St. Louis. Sales engineers in the firm are: **E. P. Jones, R. A. Philibert, A. W. Indest, Jr.,** and **Malcolm Kueneman.**

A. C. Blackman, former head of the California Division of Industrial Safety, is the newly-elected managing director of the American Society of Safety Engineers. Mr. Blackman assumed his position as chief administrative officer of the Society on February 16.

Curtis Lighting Inc., Chicago, Ill. has signed two new sales representatives, according to a recent announcement. **Thomas A. Marshall,** formerly associated with the Edwin F. Guth Co.. St. Louis, will represent Curtis in Southern Florida and **James F. Talbot** will handle sales in the Chicago area, including northern Indiana.

Robert H. Horner has joined the Military Avionics Department of Goodyear Aircraft Corp., Akron, Ohio, according to an announcement by Engineering Division Chief, **E. A. Brittenham.** Mr. Horner's responsibilities in the data processing equipment section will be concerned with electromechanical equipment development, liaison with other enginering groups and systems engineering. For the past ten years, Mr. Horner had been associated with The Wakefield Co., Vermilion, Ohio in various sales and field engineering positions.

Day-Ray Products, Inc. (supplementary lighting), South Pasadena, Calif. has named the **James Findlay** Co., Bellevue, Wash. as factory representatives in the Pacific Northwest territory and **Wilco,** Inc., Wichita, Kans. as representatives for the Mid-Continent area.

Sy Diamond has been appointed advertising and sales promotion manager for industrial and consumer products for the Amplex Corp., Long Island, N. Y. Mr. Diamond, who has been associated with the firm for five years, served as sales promotion manager for Amplex's affiliated companies, prior to this appointment.

Day-Brite Lighting, Inc., St. Louis, Mo. has announced the appointment of **M. Breeden Moore, Jr.,** former Westinghouse salesman, as sales representative for South Carolina.

Markstone Mfg. Co., Chicago, has announced the appointment of **Joseph A. Tills** as vice-president in charge of sales.

M. O. Withed has been appointed rural service manager of the Edison Electric Institute. Prior to this appointment, Mr. Withed had been associated with the Atlantic City Electric Co. for 24 years, most recently as rural service supervisor.

Quadrangle Manufacturing Co., Chicago, Ill. has announced the appointment of **John Allen Ware** & Associates, Phoe-

(Continued on page 21A)

LIKE A

Horse and Carriage

...they go together!

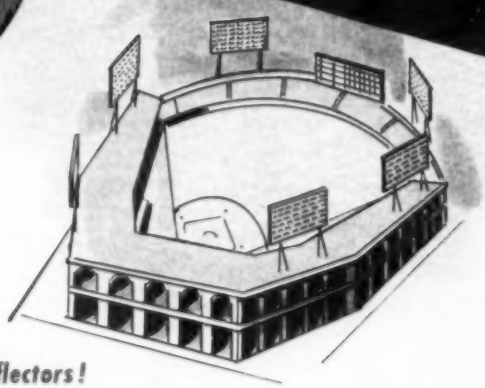
MARRIED 25 YEARS

MAJOR

Awarded an exclusive ALZAK license from ALCOA over a quarter century ago!

ALZAK

Maintains same brilliant reflective powers even after many years of use!



Sundown Draws No Curtain on Sports... thanks to MAJOR ALZAK*-PROCESSED Reflectors!

A whole nation, players and spectators alike, are now able to enjoy outdoor recreation at night—thanks in a large part to the miracle of MAJOR Alzak-Processed reflectors. Practically every major-league ballpark insists on them—as well as most tennis courts, playgrounds, stadiums, arenas.

That's why it's wise to always specify MAJOR Alzak-Processed reflectors on every outdoor lighting job that comes your way. Here is a superior process aluminum reflector that does not rust, tarnish, chip, peel—that outlasts any other known process—that gives you more brilliant results.

**A proprietory term of the Aluminum Company of America.*

FREE
Silver Anniversary Cigarette Lighter!
We'd like to have you celebrate with us—send us your Name, Company Name and Address.

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SPaulding 2-7600

it's a fact...

P&K

ALL ALUMINUM LIGHTING STANDARDS

"MOST FOR YOUR MONEY"

Before you specify another lighting standard, take a hard look at your costs. Look at the cost per unit to be sure, then consider the cost of installation. In this regard, nothing compares with the ease of handling light weight P & K aluminum standards. They speed installation, save time and labor. Then compare your maintenance costs. P & K aluminum standards never require painting, not on installation nor at any other time. How much can you save on this factor alone? As for simple good looks, P & K aluminum standards are in a class by themselves. They'll confirm your good taste as well as your sound business judgment for years to come.

You'll find a wealth of helpful information in P & K street and highway lighting brochures. Write for your copies.

HERE'S A COST CUTTING IDEA:

In this on-the-job photo, the crew is changing the glassware on the luminaire. Instead of inadequately cleaning it on the spot, they replace it with a clean one. Then, at the end of the day's run, they bring the dirty globes back to the shop for a really thorough cleaning, and out again, a day or two later to be used as replacements for others. This simple maintenance trick results in a better job, done faster, at lower costs. Of course, the P & K standard never needs maintenance.

PFAFF & KENDALL

84 FOUNDRY ST., NEWARK 5, N. J.

(Continued from page 18A)

nix, Ariz., as sales representatives for the state of Arizona.

Deaths

H. Brian Donohue, Forest City (London) Chapter.

Warren P. Shreve, Pittsburgh Section.

BOOKS AND PAMPHLETS

International Electrotechnical Vocabulary 50 (45) — Lighting, available from the American Standards Association 70 East 45th St., New York 17, N. Y., $4.00.

Prepared by the International Electrotechnical Commission in liaison with the International Commission on Illumination, this publication contains 290 terms and definitions in French and English, together with the equivalent terms in German, Spanish, Italian, Dutch, Polish and Swedish. Indices are provided for each of the eight languages used.

Research Highlights of the National Bureau of Standards, Annual Report, 1958. NBS Miscellaneous Publication 226, 138 pages, 45 cents. (Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.)

The report highlights research and development programs for fiscal year 1958 at the National Bureau of Standards. It describes a wide range of scientific studies, laboratory experiments, instrument developments and the Bureau's technical publications.

The Story of Light and Sight, teaching aids for elementary school classes, available from the Better Light Better Sight Bureau, 750 Third Ave., New York 17, N. Y.

Replacing an earlier set of aids bearing the same title, this new unit is designed to improve the pupil's understanding of the relationship of light and sight and to develop intelligent habits in the care of the eyes and the use of light for easy seeing.

The material was prepared by the Bureau's School Service Committee.

Color in Relation to Illumination Levels, by Walter C. Granville, American-Marietta Co., 101 East Ontario St., Chicago 11, Ill., Attention: Advertising Department. Price $1.00.

This manual discusses the choice of paint colors in relation to their appropriateness and compatability with low and high footcandle levels. It contains color chips and suggested colors for both types of areas.

Lighting the Modern Stage, available from Ariel Davis Mfg. Co., 3687 South State St., Salt Lake City 15, Utah. 26 pages, paper bound, 50 cents.

Illustrated with photographs and line drawings of both equipment and stage layouts, this booklet is divided into two main sections: Planning the Auditorium and Stage and Lighting the Stage. It is concerned mainly with school, church and civic auditoriums.

What is a Standard?, published by American Standards Association, 70 East 45th St., New York, N. Y.

This new brochure, available free from Dept. PR of ASA, explains the nature of standards and of American Standards and describes the functions of ASA as a national clearinghouse for Standards in the United States and as the U. S. representative in international standardization work.

American Standard C80.4 - 1958, Specification for Fittings for Rigid Steel Conduit and Electrical Metallic Tubing, published by American Standards Association, 70 East 45th St., New York, N. Y., 80 cents.

The publication of this standard, sponsored by the American Iron and Steel Institute and the National Electrical Manufacturers Association, brings the number of standards in this field to four and completes the standardization work for conduits and their components. Copies are available from Dept. PR.

NEW MEMBERS

At the meeting of the I.E.S. Council Executive Committee on March 12, 1959, the following were elected to membership. Names marked * are transfers from Associate Member Grade. Names marked ** are transfers from Student Member Grade.

ARKANSAS SECTION

Associate Member:

Linebarger, E. L., Arkansas Power & Light Co., Forrest City, Ark.

ARK-LA-TEX CHAPTER

Associate Member:

Williams, D. R., Southwestern Electric Power Co., Shreveport, La.

ARROWHEAD CHAPTER

Associate Member:

Voorhies, C. W., Magnolia Electric Co., Riverside, Calif.

BRITISH COLUMBIA SECTION

Associate Members:

Galbraith, J. J., British Columbia Electric Co. Ltd., Westview, B. C.

Gopsill, G. T., Ricketts-Sewell Electric, Vancouver, B. C.

CENTRAL NEW YORK SECTION

Member:

Miller, R. J., Charles W. Personius, Pine City, N. Y.

Associate Members:

Lynch, Kathryn L., N. Y. State Electric & Gas Corp., Binghamton, N. Y.

McCarter, R. A., N. Y. State Electric & Gas Corp., Binghamton, N. Y.

**Sullivan, D. D., Corning Glass Works, Corning, N. Y.

(Continued on page 52A)

1959 Regional Conferences — I.E.S.

Region	Place	Date
South Central and Southeastern	Grove Park Inn Asheville, N. C.	April 23-24
Southwestern	Shamrock-Hilton Hotel Houston, Texas	May 4-5
Midwestern	Pere Marquette Hotel Peoria, Ill.	May 6-8
Inter-Mountain	Continental Hotel Denver, Colo.	May 11-12
Pacific Northwest	Banff Springs Hotel Banff, Alta.	May 26-30
Northeastern	Curtis Hotel Lenox, Mass.	June 4-5
Canadian	Chateau Laurier Ottawa, Ont.	June 11-12
Great Lakes	Lafayette Hotel Buffalo, N. Y.	June 22-23

I. E. S. National and Local Officers 1958-1959

Officers and Council 1958-1959

President — GEORGE J. TAYLOR, Day-Brite Lighting, Inc., 122 E. 42nd St., New York, N. Y.

Vice-President — J. B. BROWDER, Georgia Power Co., 75 Marietta St. N. W., Atlanta, Ga.

Vice-President—RICHARD G. SLAUER, Sylvania Electric Products, Inc., One 48th St., Wheeling, W. Va.

Past-President — M. N. WATERMAN, Westinghouse Electric Corp., Bloomfield, N. J.

Past-President — KIRK M. REID, General Electric Co., Nela Park, Cleveland, Ohio.

General Secretary — J. R. CHAMBERS, Appleton Electric Co., 1701-1759 Wellington Ave., Chicago, Ill.

Treasurer — G. FRANKLIN DEAN, Toronto Hydroelectric System, 14 Carlton St., Toronto, Ont.

Directors

C. W. MCCORMICK, Connecticut Light & Power Co., P. O. Box 2010, Hartford 1, Conn.

J. DIXON MITCHELL, Westinghouse Lamp Division, 2260 Peachtree Industrial Blvd., Chamblee, Ga.

J. A. SCHNELLER, Quadrangle Manufacturing Co., Chicago, Ill.

RAY P. TEELE, National Bureau of Standards, Washington 25, D. C.

JOSEPH THOMAS, Canadian General Electric Co. Ltd., 280 Faillon St., Montreal, Que.

J. D. WHITNELL, Arizona Public Service Co., P. O. Box 2591, Phoenix, Ariz.

Regional Vice-Presidents

Canadian Region — J. CARL WILSON, J. A. Wilson Lighting & Display, Ltd., 280 Lakeshore Rd., Toronto, Ont.

East Central Region — C. C. SHOTWELL, Philadelphia Electric Co., 211 S. Broad St., Philadelphia, Pa.

Great Lakes Region—ROBERT W. BROWN, Cincinnati Gas & Electric Co., 4th and Main Sts., Cincinnati, Ohio.

Inter-Mountain Region—A. EUGENE FLEMING, General Electric Supply Co., P. O. Box 5288, Denver, Colo.

Midwestern Region—BROOKS CHASSAING, Chassaing Bros. Lighting, 7603 Forsyth Blvd., St. Louis, Mo.

Northeastern Region—RAYMOND L. SMART, Boston Edison Co., 39 Boylston St., Boston, Mass.

Pacific Northwest Region—BEVERLY TRAVIS, 407 Medical Arts Bldg., Seattle, Wash.

South Central Region—JACOB M. GENSBURGER, New Orleans Public Service, Inc., 317 Baronne St., New Orleans, La.

Southeastern Region—JAMES A. BANTON, Tampa Electric Co., Tampa, Fla.

South Pacific Coast Region—JAMES E. BARNES, Pacific Gas & Electric Co., P. O. Box 540, San Rafael, Calif.

Southwestern Region — JOHN B. DECK, JR., Texas Power & Light Co., P. O. Box 6331, Dallas, Texas.

Section and Chapter Officers 1958-1959

Alabama Section — South Central Region

Chairman—SAMUEL DAVIDSON, Alabama Power Co., 121 Dexter Ave., Montgomery, Ala.

Secretary—ROBERT P. FULMER, Westinghouse Electric Corp., 1407 Comer Bldg., Birmingham, Ala.

Alamo Section — Southwestern Region

Chairman—RICHARD W. BARNES, Route 10, Box 70, San Antonio 12, Texas.

Secretary — THOMAS F. BEACH, Southern Equipment Co., 1102 N. Cherry, San Antonio, Texas.

Arizona Section — Inter-Mountain Region

Chairman—R. E. TWEEDY, 356 E. Alvarado Road, Phoenix, Ariz.

Secretary — STANLEY S. LAMBE, Salt River Project, P. O. Box 1980, Phoenix, Ariz.

Arkansas Chapter — South Central Region

Chairman — JAMES C. VENABLE, Associated Mfg. Agents, 5218 Hawthorne Rd. Little Rock, Ark.

Secretary — LOUIS STOUT, Curtis Stout Co., P. O. Box 107, Little Rock, Ark.

Ark-La-Tex Chapter — Southwestern Region

Chairman — M. H. PERKINS, Southwestern Electric Power Co., 122 E. Broad St., Texarkana, Ark.

Secretary — K. D. HIGHTOWER, Square D Co., P. O. Box 4327, Shreveport, La.

Arrowhead Chapter — South Pacific Coast Region

Chairman — G. F. BURGESS, California Electric Power Co., 2885 Foothill Blvd., San Bernardino, Calif.

Secretary — WILLIAM H. RITTER, California Electric Power Co., P. O. Box 1029, San Bernardino, Calif.

Bluenose Chapter — Canadian Region

Chairman — D. C. MYRA, Maritime Telegraph & Telephone Co., Hollis St., Halifax, N. S.

Secretary — R. E. BUELL, Northern Electric Co. Ltd., Howe Ave., Halifax, N. S.

British Columbia Section — Pacific Northwest Region

Chairman — E. N. KOLBEINS, 768 W. 61st Ave., Vancouver 14, B. C.

Secretary — MICHAEL M. HAWKEY, 2256 W. 12th Ave., Vancouver, B. C.

Capital Section — East Central Region

Chairman — ALFRED J. RUGO, Sylvania Electric Products Inc., 2520 Oakville St., Alexandria, Va.

Secretary — K. W. COBB, 2430 Pennsylvania Ave., N. W., Washington, D. C.

Central Florida Chapter — Southeastern Region

Chairman — HUGH SAUSSY, Progress Mfg. Co., P. O. Box 2932, Orlando, Fla.

Secretary — LOWRY B. MILLER, Florida Power Corp., Winter Park, Fla.

Central Illinois Chapter — Midwestern Region

Chairman — D. N. SCHNEIDER, Central Illinois Light Co., 316-318 S. Jefferson, Peoria, Ill.

Secretary — ROBERT HOVIND, Caterpillar Tractor Co., Peoria, Ill.

Central New York Section — Great Lakes Region

Chairman — JOHN S. HANEY, Crouse-Hinds Co., 1201 Wolf St., Syracuse, N. Y.

Secretary — RUDOLPH C. SWANSON, JR., Niagara Mohawk Power Corp., 300 Erie Blvd. W., Syracuse, N. Y.

Central Oklahoma Chapter — Southwestern Region

Chairman — W. S. IRVING, General Electric Co., 4030 N. W. 10th St., Oklahoma City, Okla.

Secretary — MRS. JANICE MATA, Hunnicker Brothers, 105 E. California, Oklahoma City, Okla.

Chicago Section — Midwestern Region

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(Continued on page 27A)

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Washington
Montana
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CENTRAL FLORIDA
FLORIDA
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STATE BOUNDARIES
SECTION OR CHAPTER BOUNDARIES

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Albuquerque, N. M.	New Mexico Chapter
Allentown, Pa.	Eastern Pennsylvania Section
Amarillo, Texas	Panhandle Chapter
Atlanta, Ga.	Georgia Section
Baltimore, Md.	Maryland Section
Birmingham, Ala.	Alabama Section
Boston, Mass.	New England Section
Buffalo, N. Y.	Western New York Section
Calgary, Alta.	Chinook Chapter
Charlotte, N. C.	Tar Heel Section
Chicago, Ill.	Chicago Section
Cincinnati, Ohio	Ohio Valley Section
Cleveland, Ohio	Cleveland Section
Corpus Christi, Texas	Coastal Bend Chapter
Dallas, Texas	North Texas Section
Dayton, Ohio	Miami Valley Section
Denver, Colo.	Rocky Mountain Section
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Halifax, N. S.	Bluenose Chapter
Hamilton, Ont.	Hamilton Chapter
Hartford, Conn.	Connecticut Section
Houston, Texas	San Jacinto Section
Indianapolis, Ind.	Indiana Section
Jackson, Miss.	Mississippi Chapter
Kansas City, Mo.	Heart of America Section
Little Rock, Ark.	Arkansas Chapter
London, Ont.	Forest City Chapter
Los Angeles, Calif.	Southern California Section
Lubbock, Texas	South Plains Chapter
Memphis, Tenn.	Mid-South Chapter
Mexico City, Mexico	Mexico Chapter
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Ottawa, Ont.	Ottawa Section
Peoria, Ill.	Central Illinois Chapter
Philadelphia, Pa.	Philadelphia Section
Phoenix, Ariz.	Arizona Section
Pittsburgh, Pa.	Pittsburgh Section
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San Francisco, Calif.	Golden Gate Section
San Jose, Calif.	San Jose Chapter
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Toronto, Ont.	Toronto Section
Trois Rivieres, Que.	St. Maurice Valley Chapter
Tulsa, Okla.	Oil Capital Section
Valdosta, Ga.	Suwannee River Chapter
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Victoria, B. C.	Vancouver Island Chapter
Washington, D. C.	Capital Section
Winnipeg, Man.	Winnipeg Chapter

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Forest City Chapter
Hamilton Chapter
Maritime Chapter
Montreal Section
Ottawa Section
Quebec Chapter
St. Maurice Valley Chapter
Toronto Section
Winnipeg Chapter

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Maryland Section
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Pittsburgh Section
Virginia Section

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Cleveland Section
Miami Valley Section
Michigan Section
Northwestern Ohio Section
Ohio Valley Section
Rochester Section
Western Michigan Section
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Arizona Section
New Mexico Chapter
Rocky Mountain Section
Southern Colorado Chapter
Utah Section

MIDWESTERN REGION

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Cornhusker Section
Heart of America Section
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Iowa Section
Milwaukee Section
Ozark Chapter
St. Louis Section
Twin City Section
Twin Ports Chapter

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Connecticut Section
Eastern New York Section
New England Section
New Jersey Section
New York Section
Yankee Chapter

PACIFIC NORTHWEST REGION

British Columbia Section
Chinook Chapter
Edmonton Chapter
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Oregon Section
Puget Sound Section
Vancouver Island Chapter

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Alabama Section
Arkansas Chapter
Mid-South Chapter
Mississippi Chapter
New Orleans Section
Tennessee Valley Section

SOUTHEASTERN REGION

Central Florida Chapter
Coastal Empire Chapter
Florida Section
Georgia Section
Palmetto Section
Southeast Florida Section
Suwannee River Chapter
Tar Heel Section

SOUTH PACIFIC COAST REGION

Arrowhead Chapter
Golden Gate Section
Mother Lode Chapter
San Diego Section
San Jose Chapter
Southern California Section
Yosemite Chapter

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Alamo Section
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North Texas Section
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Mexico Chapter — Non-Region

NEW

K2 Electro-Gard*

Illuminated Exit Signs by PERFECLITE

There's 100% more Life in Every Unit

Electro-Gard Exit Units are equipped for two 25 w. lamps but only a single lamp operates at a time. When one burns out, the other comes on instantly due to an exclusive built-in electronic mechanism which works off the same voltage. The results: 100% longer illumination—100% less maintenance worry. And since both lamps do not burn simultaneously, current consumption is greatly reduced as well.

Electro-Gards are available for all surface type and recessed installations. Surface boxes are of 18 ga. press drawn steel, ½" KO's top and side. Recessed boxes are of 20 ga. press drawn steel, six ½" KO's. Both types can also be supplied in aluminum. The die formed 20 ga. steel frame is pivot hinged for easy servicing.

Surface type and recessed units may be ordered in two face styles: hinged metal stencil face, 6" letters on fired green or red glass backing—or 6" letters on fired ceramic glass panel—in four color combinations.

All units are guaranteed for five years.

For further information, mail the attached coupon today!

* Patent Pending

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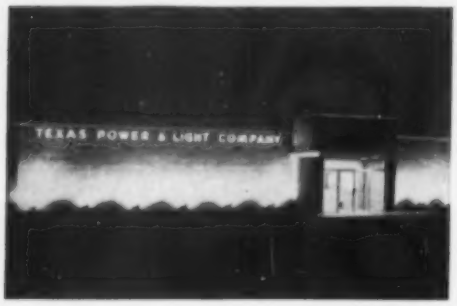
Revere Outdoor Lighting Report

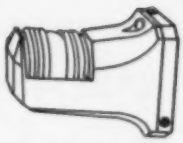
Revere ELECTRIC MFG. CO.

Lighting a building exterior



The Problem: To highlight a new building through the use of dramatic lighting of the building exterior. Fixtures must be attached to the building itself.

The Answer: Ten Revere No. 3151 Underneath Floodlights were installed to provide a source of uniform, glare-free light for the exterior walls of the building. Underneath Floodlights were chosen because they are unobtrusive and because they project a wide, flat pattern of light. Fixtures are completely weather-tight and insect-proof.

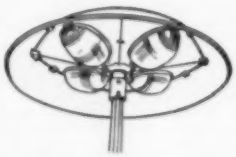


No. 3151 Underneath Floodlight

Lighting a shopping center parking lot

The Problem: To illuminate the large parking lot of a modern shopping center, providing a safe, attractive place for shoppers to leave their automobiles.

The Answer: Revere Ultra-Lites, multiple mercury luminaires, were installed throughout the parking area. The square light patterns were overlapped to achieve a uniform, glare-free light level. The use of Ultra-Lites cut pole requirements by more than 50% because of much higher utilization of light per fixture.



No. 5442 Ultra-Lite

Lighting a residential street

The Problem: To light a quiet neighborhood street with moderate-level illumination concentrated on the street with lesser amount on the sidewalk.

The Answer: Revere Urban-Lite luminaires were installed on one side of the street. Projection pattern of units made possible the even lighting of street and additional light on sidewalk with minimum stray light entering adjacent homes. Urban-Lite is an economical way to utilize smaller, highly efficient mercury lamps.

No. 2100 Series Urban-Lite

Write for Revere's complete catalog of outdoor lighting equipment

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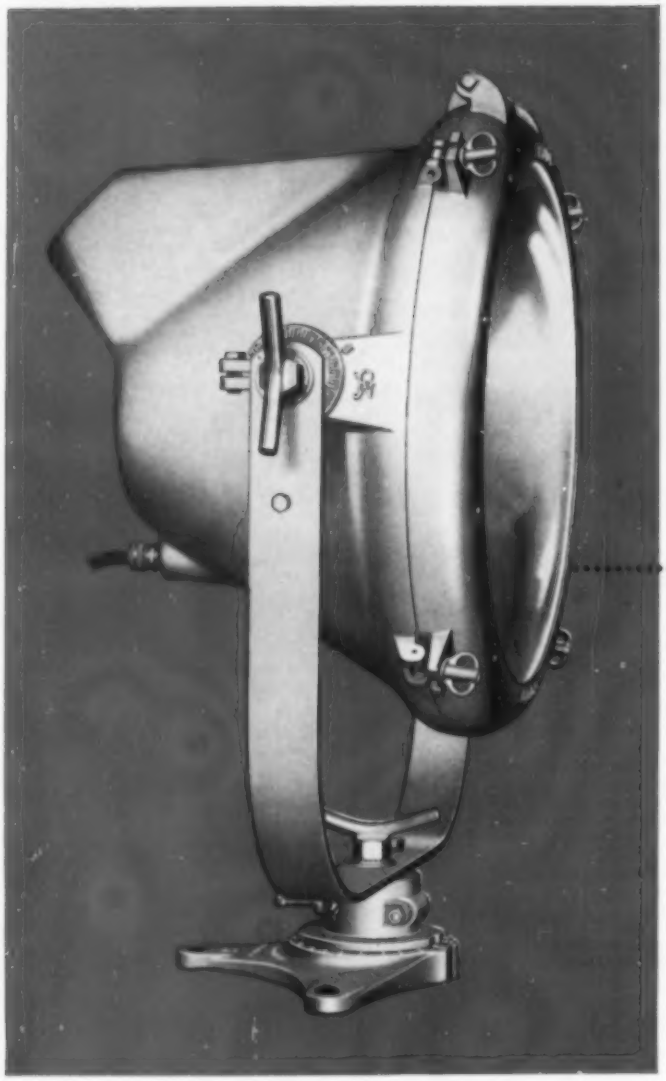
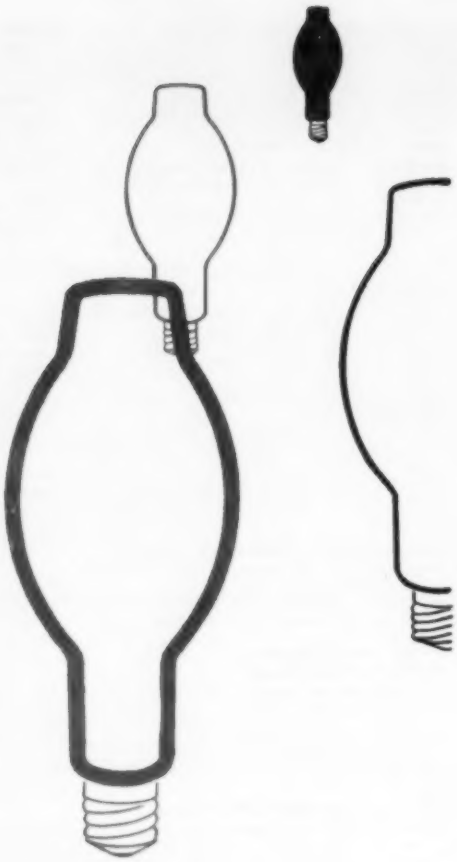
(*Continued on page 40A*)

NEW
PYLE-NATIONAL MERCURY VAPOR FLOODLIGHTS





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(Continued from page 29A)

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COMMITTEE PERSONNEL

COMMITTEES 1958-1959

All committees are appointed by the President, subject to approval of the Council. Except as provided in the Constitution, appointments terminate at the time of the first Council meeting of the following administration. The scope of each committee is indicated.

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J. B. Browder, Vice-President, ex-officio member of all Technical Committees.

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G. J. Taylor, Chairman, Day-Brite Lighting Inc., 161 East 42nd St., New York 17, N. Y.

J. B. Browder	G. F. Dean
J. R. Chambers	R. G. Slauer

BOARD OF FELLOWS — To evaluate the eligibility of candidates for transfer to grade of Fellow according to procedures approved by Council.

Edward Rambusch, Chairman, Rambusch Decorating Co., 40 West 13th St., New York 11, N. Y.

Willard Allphin	L. H. Brown
J. W. Bateman	J. S. Hamel

B. J. Jensen

FINANCE — To have direct supervision of the financial affairs of the Society and to present to the Council an annual report on its financial condition. To make recommendations to the Council as to the investment of moneys and upon all specific appropriations. To prepare and submit for approval of Council not later than the first new Council meeting, a budget of income and expense for the ensuing fiscal year.

W. P. Lowell, Jr., Chairman, Sylvania Electric Products Inc., 60 Boston St., Salem, Mass.

A. C. Barr	G. F. Dean, ex-officio
H. S. Beagle	R. M. Zabel

GENERAL BOARD OF EXAMINERS — To investigate the qualifications of all applicants for admission to membership; to elect or reject applicants for the grade of Associate Member and Student Member, to report such action to the Council; and to make recommendations to the Council regarding applications for transfer or election to the grade of Member or Retired Member, and for transfer to the grade of Member Emeritus.

H. E. D'Andrade, Chairman, General Electric Co., Inc., 570 Lexington Ave., New York 22, N. Y.

S. W. Bruun	Taylor Barr
B. S. Benson	O. B. Goldsmith
F. C. Breckenridge	J. W. Griffith
James Cox	Ted Sargent
C. M. Cutler	G. A. Trosper
H. F. Davidson	George Wakefield
Kurt Franck	L. E. Barbrow

R. S. Wiseman

PAPERS — To procure, review and approve all technical papers and discussions thereof, for presentation before National Conferences of the Society.

F. W. Sell, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

Brooks Chassaing	R. W. Morris
Eve Freyer	J. S. Schuchert
W. P. Lowell, Jr.	F. W. Sell

Home Lighting Data Sheets

Eve Freyer, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

REVIEWING SUBCOMMITTEE

Lillian Eddy	Jan Reynolds
Katharine T. Goodall	John Kaufman

CONTRIBUTING SUBCOMMITTEE

Marianne Battig	Caroline B. Mourning
Nelson Bleisch	Aileen Page
Kathleen Downey	Grace Schoeni
Stella Fetzer	R. C. Stockbridge
Melrose Franklin	Margaret Summers
Ruth P. Maddox	Mary Taepke
Dorothy McGregor	Dorothea Underwood

Blanche Waggener

GENERAL COMMITTEES

ADVANCE PLANNING — To study the long range objectives of the Society — its operation, program, publication activities, membership classifications and financial structure, and to make recommendations to Council.

J. Dixon Mitchell, Chairman, Westinghouse Electric Corp., 2260 Peachtree Industrial Blvd., Chamblee, Ga.

A. C. Barr	C. W. McCormick
W. P. Lowell, Jr.	L. C. Twichell

J. D. Whitnell

ADVISORY BOARD TO THE PRESIDENT — To examine the organization, accomplishments, and assignments of committees and prepare not later than July 1 of each year a proposed list of committees and personnel; and to evaluate costs and benefits of present and proposed Society services.

J. B. Browder, Chairman, Georgia Power Co., 75 Marietta St. N. W., Atlanta 1, Ga.

J. R. Chambers	K. M. Reid
G. F. Dean	R. G. Slauer

ALLIED ARTS — To encourage and assist local competitions in allied arts, in cooperation with technical committees and interested local groups.

J. D. Whitnell, Chairman, Arizona Public Service Co., P. O. Box 2591, Phoenix, Ariz.

K. A. Staley, Secretary, General Electric Co., Nela Park Cleveland 12 Ohio.

Carl Albach	Thomas Mackesey
D. J. Bourdon	R. B. McFarland
R. W. Brown	Howard McKinley
Jack Cottingham	Onnie Monkki
Alan R. Cripe	M. B. Moore
Roy Dahlin	Joseph Morbito
Frank Feagans	Robert A. Nevin
John Flynn	Roy Palmer
A. B. Gallion	Kenneth Parsons
Herbert Hoffman	J. C. Penafeather
A. R. Keeler	Harry Rodman
Lucien Kight	J. A. Russell
J. O. Kraehenbuehl	B. J. Sabaroff
William Lam	G. E. Shoemaker

BOARD OF NOMINATION — To prepare a nomination ticket containing the names of those who are deemed best suited to serve as officers and directors in positions to be filled at the ensuing election.

R. F. Hartenstein, Chairman, Ohio Edison Co., Akron, Ohio.

K. M. Reid	M. N. Waterman

and regional representatives

CONSTITUTION AND PROCEDURES — To prepare proposed amendments to the Constitution and By-laws, to prepare statements of policies and procedures consistent with the Constitution and By-laws, and to report to Council.

R. F. Hartenstein, Chairman, Ohio Edison Co., Akron, Ohio.

G. F. Dean	Glenn Park
C. C. Keller	Walter Sturrock

L. C. Twichell

DEFENSE COORDINATING — To contact various government agencies concerned with national security suggesting cooperation and participation in specific projects as an aid to solution of their problems. Recommending the placement of lighting study projects in present committees or the appointment of study project committees to the Society President and to expedite such study projects and guide accepted reports into proper government channels.

J. W. Bateman, Co-Chairman, Canadian General Electric Co., Ltd., 212 King Street, W., Toronto, Ont.

A. P. Wakefield, Co-Chairman, The Wakefield Co., 731 S. Water St., Vermilion, Ohio.

H. R. Blackwell	O. P. Cleaver
R. B. Brown, Jr.	John S. Walsh

HISTORICAL — To assemble and make available for current reference and to prepare in suitable and durable form for posterity such historical facts, printed memorabilia, photographs, voice records, museum specimens and allied items as may be judged worthy of composing a continuing digest of the record of the Society's history.

S. B. Williams, Chairman, Brooks St., Jamestown, R. I.

Julius Daniels, Vice-Chairman, Boston Edison Co., 39 Boylston St., Boston, Mass.

W. F. Bear	S. G. Hibben
James Cravath	H. L. Logan
Leo Dolkart	J. L. Stair
C. A. B. Halvorson	G. E. Stickney

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LIGHTING SERVICE — To stimulate and promote the discussion and practical application of lighting recommendations.

C. W. McCormick, Chairman, Connecticut Light & Power Co., P. O. Box 2010, Hartford, Conn.

A. C. Brodeur, Jr.	Joseph Thomas
Roy Dahlin	Carlton Thompson
W. E. Damuck	C. E. Waldron
R. F. Hartenstein	M. N. Waterman
J. D. Mitchell	J. D. Whitnell

J. C. Wilson

MEDAL AWARD — To evaluate the eligibility of candidates for award of the IES Medal according to procedures approved by the Council.

R. F. Hartenstein, Chairman, Ohio Edison Co., Akron, Ohio.

Julius Daniels	Hoyt P. Steele
M. B. Hastings	A. F. Wakefield
H. H. Magdsick	M. N. Waterman
K. M. Reid	J. F. Whitehead

MEMBERSHIP — To develop plans and supervise the operation of the individual membership activity of the Society.

J. C. Forbes, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Brooks Chassaing	Gerald Marks
Jack T. Cottingham	Max D. Orr
Roy E. Dahlin	Eustece J. Perkins
Earl I. Dinsmore	Joseph Thomas
Mildred S. Ditzel	Allan S. Turner, Jr.
Judd Lough	John S. Williams, IV

NATIONAL TECHNICAL CONFERENCE — To be completely responsible, subject to the approval of Council, for the general coordination of all conference activities, for selecting and recommending time and place, for review of the plans and budgets of the National Technical Conference Executive Committee, and in cooperation with the Papers Committee for the satisfactory time allocation for the Technical Papers sessions, according to Procedures and Policies as adopted by Council.

C. L. Amick, Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis 7, Mo.

J. A. Barnes	J. D. Mitchell
J. W. Bateman	P. M. Rutherford
Brooks Chassaing	J. S. Schuchert
J. C. Forbes	F. W. Sell
W. P. Lowell, Jr.	C. C. Shotwell
C. W. McCormick	J. S. Walsh

J. C. Wilson

1959 Conference Executive Committee

J. S. Walsh, Chairman, Pacific Gas & Electric Co., 245 Market St., San Francisco, Calif.

Arthur S. Tylor, Operations Vice-Chairman, 1037 Cortez Ave., Burlingame, Calif.

William L. Friend, Program Vice-Chairman, Sylvania Electric Products Inc., 1611 Adrian Dr., Burlingame, Calif.

George Baker	Guy de Leuze
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Charles Buchanan	R. L. Sawyler, Jr.
J. H. Burson	D. D. Scarff
W. A. Cyr	R. A. D. Schwartz
Frank Duhme	G. A. Trosper

PUBLIC RELATIONS AND INFORMATION — To prepare and disseminate information about the activities, accomplishments, programs, objectives and policies of the Society and about the place of illuminating engineering in modern society; to formulate and submit public relations policies and plans to the Society.

W. A. Dalrymple, Chairman, Amalgamated Electric Corp., Ltd., 384 Pape Ave., Toronto, Ont.

R. E. Ballard	E. H. Gallet
W. A. Cyr	John Ronayne
John Eichorn	R. W. Sclater

L. E. Tayler

REGIONAL ACTIVITIES — To represent the respective Regions before the Council and to keep the Council informed regarding the affairs of the Regions. To stimulate Society activities, to encourage joint meetings of Sections and Chapters including Regional Conferences within the respective Regions, and to promote the expansion of the Society.

R. G. Slauer, Chairman, Sylvania Electric Products Inc., One 48th St., Wheeling, W. Va.

J. A. Banton	A. Eugene Fleming
J. A. Barnes	J. M. Gensburger
Robert Brown	C. C. Shotwell
Brooks Chassaing	R. L. Smart
J. B. Deck, Jr.	B. A. Travis

J. Carl Wilson

RESIDENCE LIGHTING FORUMS — To stimulate and assist the Residence Lighting Forums of the Society and to encourage the formation of additional Forums. To conduct a Residence Lighting Forum in connection with the National Technical Conference.

Virginia Skinner, Chairman, Long Island Lighting Co., 175 Old Country Road, Hicksville, N. Y.

Marianne Battig	Ruth Lieb
Dorothy Davis	Ruth Morris
Eve Freyer	T. T. Peake
Benjamin Goodman	Mary Pelkonen
Robert Haskell	L. A. Russell
William Hinckley	J. Vernon Sharp
T. S. Kelly	Margaret Summers

Mary Webber

SUSTAINING MEMBERSHIP — To develop plans and supervise the operation of the Sustaining Membership activity in the Society according to the Procedures and Policies adopted by Council.

W. W. Booth, Chairman, General Electric Supply Co., 1260 Boston Ave., Bridgeport, Conn.

B. F. Benning	C. C. Shotwell
E. H. Church	L. E. Tayler
E. C. Huerkamp	E. J. White

TRUSTEES, I.E.S. HEADQUARTERS RETIREMENT PENSION PLAN

M. N. Waterman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

G. F. Dean	W. P. Lowell, Jr.

K. M. Reid

TASK COMMITTEES

I.E.S. - U. S. PUBLIC HEALTH SERVICE — To outline a method of making a survey of the visual factors of the working environment and the workers' vision and evaluating the findings in terms of visual comfort and effectiveness and eye health.

J. F. Parsons, Chairman, Niagara Mohawk Power Corp., Electric Bldg., Buffalo 3, N. Y.

H. N. Doyle, Vice-Chairman, U. S. Public Health Service, Washington 25, D. C.

Tula Brocard	L. E. Duval, Jr.
L. J. Cahill	A. L. Koven
George Clayton	R. P. Teele

RESEARCH FINANCING — To determine how the long range financial needs of the Illuminating Engineering Research Institute research program may be met.

Kirk M. Reid, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

J. S. Schuchert	A. F. Wakefield
R. G. Slauer	M. N. Waterman
E. M. Strong	J. F. Whitehead

TO STUDY the scope, objectives, policies of the National Technical Conference.
C. L. Amick, Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis 7, Mo.

B. S. Benson	J. D. Mitchell
J. C. Forbes	J. C. Wilson

TO WORK with NEMA on the coordination of lighting exhibits.

R. G. Slauer, Chairman, Sylvania Electric Products Inc., Wheeling, W. Va.

C. L. Amick R. M. Taylor

TECHNICAL COMMITTEES

AVIATION AND SIGNAL — To study the application of light and lighting to the spaces and functions involved in the operation of aircraft.

M. A. Warskow, Chairman, Airborne Instrument Laboratories, Inc., 160 Old Country Road, Mineola, N. Y.

F. C. Breckenridge, Technical Secretary, National Bureau of Standards, Washington 25, D. C.

Aircraft Lighting

Warren Hulke, Chairman, Soderberg Manufacturing Co., 628 S. Palm Ave., Alhambra, Calif.

W. E. Woodson, Secretary, Convair Corp., Division of General Dynamics, P. O. Box 1950, San Diego, Calif.

W. C. Fisher, Papers Coordinator, Bureau of Aeronautics, Dept. of Navy, Washington 25, D. C.

F. C. Ashe	G. K. C. Hardesty
E. Boghosian	W. D. Howell
F. B. Brady	J. P. Hoxie
F. C. Breckenridge	W. A. Jensen
D. I. Coggins	D. C. Miller
H. A. Cramer	M. A. Mortensen
R. K. Davis	T. H. Projector
C. A. Douglas	Norbert Schwenkler
I. Fagin	F. C. Shipley
S. R. Goldfarb	R. J. Stefany
P. H. Greenlee	R. A. Stone

M. A. Warskow

BIBLIOGRAPHY

Frank Ashe, Chairman, Kopp Glass Inc., Swissvale, Pittsburgh 18, Pa.

COCKPIT LIGHTING

Dean Pierce, Chairman, Lockheed Aircraft Corp., Burbank, Calif.

EXTERIOR LIGHTING

Mel Clayton, Chairman

INTERIOR LIGHTING

Wesley Woodson, Chairman, Convair Division of General Dynamics Corp., P. O. Box 1950, San Diego 12, Calif.

LAMPS (SMALL)

M. A. Mortensen, General Electric Co., Nela Park, Cleveland 12, Ohio.

Ground Lighting

R. J. Stefany, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

J. P. Hoxie, Secretary, Corning Glass Works, Corning, N. Y.
C. A. Douglas, Papers Coordinator, National Bureau of Standards, Washington 25, D. C.

*J. F. Angier	L. W. Hornfeck
F. C. Ashe	*Warren Hulke
E. Boghosian	W. A. Jensen
F. B. Brady	C. E. Leberknight
F. C. Breckenridge	C. J. McDonald
W. D. Callaghan	J. K. Newell
F. E. Carlson	W. A. Pennow
P. B. Clark	F. C. Shipley
G. K. Clement	L. C. Simpson
D. I. Coggins	R. A. Stone
V. Converso	L. C. Vipond
E. A. Cuttrell	A. E. Wallis
O. F. Farris	M. A. Warskow
D. M. Finch	H. A. Williams
J. S. Haney	J. P. Wilson
R. D. Harts	A. B. Winters

*ex-officio

APPROACH LIGHTING

D. I. Coggins, Chairman, Sylvania Electric Products Inc., Photoflash Division, 60 Boston St., Salem, Mass.

E. A. Cuttrell	O. F. Farris
C. A. Douglas	G. M. Kevern

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NEW COOL SOLA SLIMLINE BALLAST

Sola ballasts guard your reputation with coolest coils and capacitors, easily pass "in-fixture" heat tests

Sola's new 650-110 ballast for two F96T12 or two F72T12 slimline lamps offers premium performance at only slight additional cost. This new CBM-certified ballast was tested in a totally-enclosed, four-lamp fixture mounted against fibrous acoustical material. Room ambient was 25°C. Maximum temperatures recorded were: case "hot spot" 86°C, capacitor 70°C. Each temperature was well within insulation limits and U.L. fixture requirements. Sola outperformed competitive, premium-priced ballasts tested under these same severe conditions. (Request Bulletin FL-356 for details and test results.)

Men who install, furnish, or specify fixtures know that "in-fixture" ballast performance is what really counts to the man who's buying the light and who insists on every lumen he's paying for. They know that Sola's all-CBM-certified ballasts give trouble-free, cool, efficient service . . . full light output and full ballast life.

Fixture manufacturers are invited to evaluate this new, cool slimline ballast (Cat. No. 650-110) in their own fixtures. Request test samples or Bulletin FL-356 from ***Sola Electric Co.,*** A Division of Basic Products Corporation, ***4633 W. 16th Street, Chicago 50, Illinois***

HOW CBM ASSURES YOU BETTER BALLAST VALUE

ETL checks 12 to 14 specified ballast characteristics on all Certified types in production by each manufacturer, verifies compliance by test . . . and does it every month!

THIS is important: Because if any ballast fails to measure up, the right to carry the emblem "Certified CBM by ETL" is withdrawn.

What characteristics are checked? The operating qualities which the American Standards Association has determined will give dependable, rated performance from the lamps with which the ballasts are designed to be used. These constitute the CBM Specification and assure:

High power factor • High light output • Positive starting • Rated lamp life • Limit on heat rise • Control for steady light • Quiet operation

From these qualities come practical benefits: Up to 2,500 hours more lamp life than with ordinary ballasts; as much as 40% more light output; and savings on installation . . . with less wire, fewer circuits needed for fixtures CBM equipped . . . fewer fixtures for the same level of light.

For the latest facts on why it pays to specify fixtures equipped with Certified CBM Ballasts, ask us to send you CBM NEWS.

CBM CERTIFIED by ETL

CERTIFIED BALLAST MANUFACTURERS

2112 KEITH BUILDING
CLEVELAND 15, OHIO

Participation in CBM is open to any manufacturer who wishes to qualify

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AVIATION LAMPS (LARGE)

F. E. Carlson, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

J. J. Bouvier — R. J. Stefany
R. D. Hartz — L. C. Vipond
S. C. Peck — A. E. Wallis

BIBLIOGRAPHY

F. C. Ashe, Chairman, Kopp Glass Inc., Palmer St., Swissvale, Pittsburgh 18, Pa.

T. M. Edwards — J. P. Hoxie

HELIPORT LIGHTING

V. E. Converso, Chairman, Port of New York Authority, 111 Eighth Ave., New York, N. Y.

J. S. Haney — H. Higgins
R. D. Hartz — E. G. Rudberg
L. C. Vipond

RUNWAY LIGHTING

A. E. Wallis, Chairman, Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio.

L. Achitoff — R. C. Herner
G. K. Clement — W. A. Jensen
C. A. Douglas — C. J. McDonaio
L. C. Vipond

SEADROME LIGHTING

R. D. Hartz, Chairman, Bureau of Aeronautics, Navy Department, Washington, D. C.
R. C. Preston — G. A. Rodney
J. E. Wesler

SERVICE AREA LIGHTING

E. B. Karns, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

R. H. Goodman — J. K. Newell
W. A. Jensen — H. A. VanDusen
H. W. Wenson

TAXIWAY LIGHTING

H. B. Decker, Chairman, Federal Aviation Agency, Columbian Bldg., 416 - 5th St. N. W., Washington, D. C.

G. K. Clement — R. L. Paugh
V. Converso — R. Pierce
J. F. Davis — E. G. Rudberg
J. D. McKinney — H. A. Williams

Signal Lighting

J. F. Angier, Chairman, 14 Valley View Ave., Washington 12, D. C.

T. G. Andrews — F. C. Breckenridge
H. R. Blackwell — C. A. Douglas
W. E. K. Middleton

COLOR — To study, evaluate and report on the effect of color in relation to the art and science of illumination.

R. C. Allison, Chairman, Engineering and Design Dept., The T. Eaton Co., Ltd., 190 Yonge St., Toronto 1, Ont.

W. E. Carswell — G. F. Dean

DAYLIGHTING — To study the problems involved in daylighting, develop recommended practices and report thereon.

J. W. Griffith, Chairman, Southern Methodist University, Industrial Engineering Dept., Dallas, Texas.

W. J. Arner — E. M. Linforth
L. E. Barbrow — W. F. Little
R. L. Biesele, Jr. — T. H. MacDonald
A. A. Brainerd — R. W. McKinley
H. S. Bull — E. C. Miles
Doyt Early — F. W. Mowrey
Benj. H. Evans — Philip O'Brien
W. B. Ewing — R. H. Reed
C. D. Gibson — F. K. Sampson
B. F. Greene — Paul W. Seagers
J. S. Herbert — D. E. Spencer
R. C. Kendall — K. C. Welch
H. F. Kingsbury — O. F. Wenzler
M. C. Kirkpatrick — C. J. Youngblood

Revision of Recommended Practice for Daylighting

R. W. McKinley, Chairman, Pittsburgh Plate Glass Co., 1 Gateway Center, Pittsburgh 22, Pa.

W. J. Arner — R. C. Kendall
E. W. Conover — H. F. Kingsbury
W. B. Ewing — E. M. Linforth
B. F. Greene — T. H. MacDonald
R. M. Hanes — F. W. Mowrey
J. S. Herbert — C. J. Youngblood

DESIGN PRACTICE — To study published data on coefficients of utilization, room indexes, maintenance coefficients and other elements entering into calculations for lighting design; develop standard methods for use in Society publications and report thereon.

G. W. Clark, Chairman, Sylvania Electric Products Inc., One 48th St., Wheeling, W. Va.

Ward Harrison — H. A. Odle
J. J. Neidhart — E. H. Salter
Phelps Meaker — R. S. Wiseman

EDUCATION — To study and encourage lighting education and training for professional careers in schools, colleges and elsewhere; to prepare educational and training material on fundamental and advanced concepts of light and illumination, and to further its adoption in courses conducted by Sections and Chapters.

Alston Rodgers, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Robert Allen — Gerald Marks
B. F. Avery — Roy A. Palmer
A. M. Bacalar — J. F. Parsons
O. P. Cleaver — R. C. Putnam
E. L. Fairchild — T. H. Shepherd
D. M. Finch — J. L. Tugman
W. A. Hedrich — Wm. Weibel
P. H. Hildebrand — R. S. Wiseman
H. W. Horn — R. E. Wozniak
R. R. Lusk — I. A. Yost
C. W. Zersen

ADVISORY MEMBERS

H. H. Magdsick — E. M. Strong

Revision of I.E.S. Courses

C. W. Zersen, Coordinator, Chicago Lighting Institute, 140 S. Dearborn St., Chicago, Ill.

Preparation of Brochure on "Opportunities in Illuminating Engineering"

J. L. Tugman, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Revision of "Lighting Design Problems" Course

R. R. Lusk, Chairman, Commonwealth Edison Co., 7601 S. Lawndale Ave., Chicago, Ill.

Gerald Marks — J. F. Parsons
William Weibel

Revision of "Lighting Fundamentals" Course

R. E. Wozniak, Chairman, Chicago Lighting Institute, 140 S. Dearborn St., Chicago, Ill.

Robert Allen — B. F. Avery
A. M. Bacalar

HANDBOOK REVISION—To revise and arrange the technical content of the Handbook; to lay out, plan and arrange for development of individual sections primarily through appropriate technical committees; to consult with the Publications Committee on its presentation of a suitable publication budget for Council approval; to be responsible to Council for the accuracy and treatment of material including the format and paging.

J. J. Neidhart, Chairman, The Miller Co., Meriden, Conn.

A. S. Almryde — W. H. Kahler
George Clark — R. W. Morris
Bruce Jensen — E. M. Strong

IES-ASAE (American Society of Agricultural Engineers), formerly Farm Lighting — To study the application of light and lighting of farm buildings, surrounding work areas and other rural locations and to report thereon.

Morris Lloyd, Chairman, Niagara Mohawk Power Corp., Buffalo 3, N. Y.

Ervin Baker — J. P. Schaenzer
J. P. Ditchman — M. O. Withed
D. E. Wiant

IES-ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Joint Committee — To study the relationship between lighting and various factors that enter into the thermal environment and report thereon.

A. T. Jorn, Chairman, ASHRAE Research Laboratory, 7218 Euclid Ave., Cleveland, Ohio.

INDUSTRIAL — To initiate, follow up and coordinate lighting study projects in the industrial field, review the reports of the various subcommittees in this field and make recommendations to Council.

L. G. Parks, Chairman, Ebasco Services, Inc., 2 Rector St., New York, N. Y.

E. Balogh — Norman Kridel
A. A. Brainerd — E. A. Linsday
R. E. Hars — Howard Long
W. H. Kahler — D. J. O'Neill
Leo G. Stahlhut

Aircraft Manufacturing

J. G. Felton, Jr., Chairman, Sylvania Electric Products, Inc., 100 Fordyce St., Dallas, Texas.

Robert S. Clubley

Clothing

Norman Kridel, Chairman, Rochester Gas & Electric Co., 89 East Ave., Rochester, N. Y.

Electronics Industry

R. S. Clubley, Chairman, General Electric Co., Large Lamp Dept., 2747 South Malt Ave., Los Angeles 22, Calif.

Graphic Arts

Ralph Enghouser, Chairman, Sylvania Electric Products Inc., 4700 Parkside Ave., Philadelphia, Pa.

Outdoor Production Areas

H. A. Cook, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

Donald R. Brown — D. J. O'Neill
William Coffey — W. R. Preece, Jr.
R. E. Faucett — G. L. Sealy
E. I. Feak — Fred Snider
Theodore Summers

Sawmills

James Barnes, Chairman, Pacific Gas & Electric Co., P. O. Box 540, San Rafael, Calif.

INSTITUTIONS — To initiate, follow up and coordinate lighting study projects in the field of public buildings and private institutions, review the reports of the various study subcommittees in this field and make recommendations to Council.

R. D. Bradley, Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis, Mo.

B. F. Avery — C. N. Laupp
J. H. McCulloch

Churches

George Shoemaker, Chairman, Philadelphia Electric Co., 211 S. Broad St., Philadelphia 5, Pa.

John Adams — T. Norman Mansell
Anthony L. Bleecker — A. C. Sangster
Henrik W. Olsen

Dining Areas

George Gilleard, Chairman, Curtis Lighting Inc., 6135 W. 65th St., Chicago 38, Ill.

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Hospitals

N. L. Griffin, Chairman, Dept. of Health, Education & Welfare, Public Health Service, Div. of Hospital & Medical Facilities, Washington 25, D. C.

John Adams	H. L. Logan
H. W. Alexander	R. C. Putnam
L. J. Buttolph	Paul Seagers
E. H. Greppin	Howard Sharp

Hotels

C. I. Sayles, Chairman, School of Hotel Administration, Cornell University, Ithaca, N. Y.

C. L. Cottrell	J. Fassett
H. E. D'Andrade	Francis Keally
Myrtle Fahsbender	F. B. Mills

LIGHT CONTROL AND EQUIPMENT DESIGN— Collect and correlate the knowledge and data on means and methods of controlling, directing, reflecting, transmitting and diffusing light and on the principles and practices of equipment design.

John T. McLaughlin, Chairman, Kelso-Burnett Electric Co., 223 W. Jackson Blvd., Chicago 6, Ill.

J. N. Robertson, Vice-Chairman, Los Angeles Dept. of Water and Power, Design and Construction Div., 405 S. Hill St., Los Angeles, Calif.

Milton Buzan, Secretary, Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis, Mo.

G. R. Baumgartner	J. S. Hamel
Warren O. Benjamin	Maurice E. Robertson
Eric H. Church	William Weibel
C. M. Holden	F. C. Winkler

Paul Woodland

LIGHT SOURCES — To correlate and report available information as to the physics of light and light production and the characteristics of current light sources.

George Freeman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Herbert A. Anderson, Vice-Chairman, Duro-Test Corp., N. Bergen, N. J.

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MAINTENANCE — To study the elements contributing to maintenance factors; set up the framework of typical field studies to determine factors; and to stimulate the prosecution of such studies by appropriate agencies.

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George Evans, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

NOMENCLATURE — To define the terms and standards of illumination, and endeavor to obtain uniformity in nomenclature.

S. K. Guth, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

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OFFICE — To study the lighting requirements of office lighting tasks, develop suitable lighting recommendations and report thereon.

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W. S. Fisher, Secretary, General Electric Co., Nela Park, Cleveland 12, Ohio.

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PROGRESS — To keep in touch with developments in the art of lighting throughout the world and prepare a yearly review of achievements in the art of illuminating engineering for inclusion in ILLUMINATING ENGINEERING.

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M. K. Strang, Vice-Chairman, Curtis Lighting of Canada Ltd., 195 Wicksteed Ave., Leaside, Toronto 17, Ont.

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PUBLIC CONVEYANCES — Interior Lighting — To study the application of light to all public areas in conveyances used for passenger transportation, including particularly trains, buses, ships, street railways and subways, and report thereon.

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Marine Transportation

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QUALITY AND QUANTITY OF ILLUMINATION. Recommendations for — To prepare recommendations of illumination levels, brightness limits and brightness relationships in form applicable to practices.

J. J. Neidhart, Chairman, The Miller Co., Meriden, Conn.

Willard Allphin	S. K. Guth
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J. M. Chorlton	D. W. Rowten
E. H. Church	E. M. Strong
Lester Geis	M. A. Warskow
J. W. Griffith	W. W. Weld

RESIDENCE — To study and report on the application of light and lighting in residences; to develop performance recommendations for residence luminaires and to prepare necessary educational aids.

W. F. Little, Chairman, 75 Dalton Rd., Yonkers 2, N. Y.

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Myrtle Fahsbender	Elizabeth A. Meehan
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Measurement of Performance Characteristics of Portable Lamps

Kaye Leighton — Priscilla Presbrey

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Revision of "Contemporary Lighting in Modern and Traditional Interiors"

Myrtle Fahsbender, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

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Training Outline

Mary B. Taepke, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

Elizabeth A. Meehan

ROADWAY — To establish the scientific principles underlying street and highway lighting; to collect data on the results of the application of such principles to actual practice; to prepare such reports thereon as will assist technicians and benefit the public.

Dana W. Rowten, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

Thomas J. Seburn, Vice-Chairman, Bureau of Highway Traffic, Strathcona Hall, Yale University, New Haven, Conn.

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(*Continued on page* 36A)

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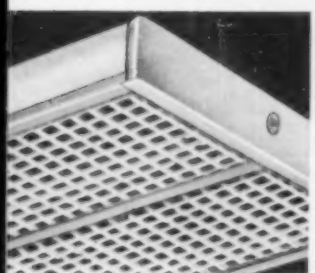

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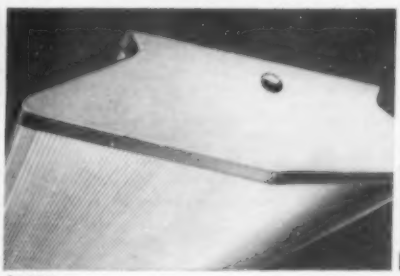

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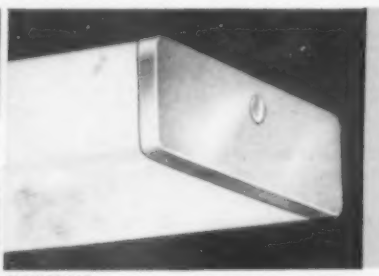

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J. C. Boggs — John Johnson

SIGN LIGHTING — To study the lighting of signs, both exterior and interior and report thereon.

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R. E. Faucett — E. E. Kinney
H. B. Fletcher — R. J. Neu
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M. W. Ross, Secretary, Commonwealth Edison Co., 72 W. Adams St., Chicago 90, Ill.

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(*Continued on page* 38A)

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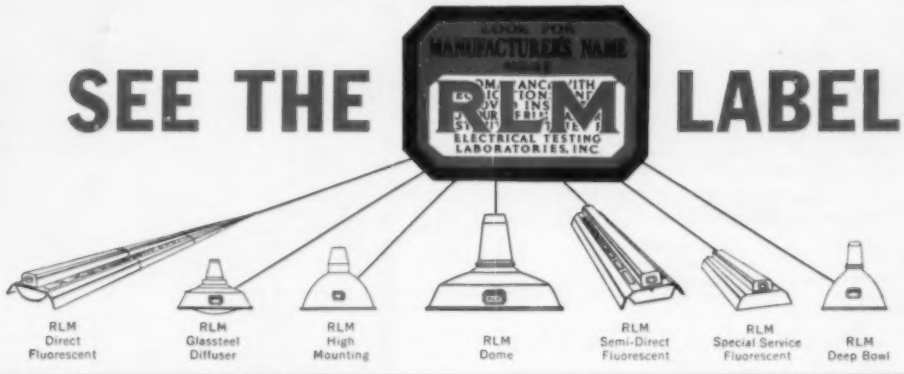

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(*Continued from page 36A*)

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General Guide on Photometry

R. P. Teele, Chairman, National Bureau of Standards, Washington, D. C.

Guide for Determination and Specification of Diffusion and Hiding Power of Fixture Diffusing Materials

G. E. Davidson, Chairman, Hydro-Electric Power Commission, 620 University Ave., Toronto, Ont.

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Guide for Electrical and Photometric Measurements of Mercury Lamps

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Guide for Interpretation of Test Data and Results

S. F. Downey, Chairman, Wheeler-Fullerton Lighting Div., Franklin Research Corp., 275 Congress St., Boston, Mass.

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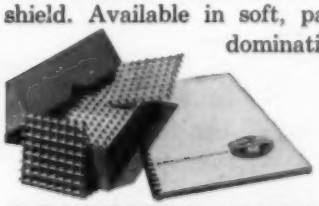
Four-foot widths (most any length) widen the adaptability of all-aluminum Columbia louvers in both ½″ and 1″ cube cells. With rigidity and perfect alignment an integral characteristic of Columbia louvers, wider panels mean less material and less labor required for suspension systems...fewer exposed T-bars, too. Koldbond louvers never sag, crack or break...give symmetry of design as they shield. Available in soft, pastel colors created to complement decor without dominating. You must see our louvers!



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New L-M Post Top Light Combines Appearance with High Efficiency

The new L-M PTL (Post Top Luminaire) combines decorative appearance with a highly efficient optical system. It is specially suitable for lighting driveways, residential and institutional grounds, schools, stores, subdivisions, parks, swimming pools, railway platforms, bus stations, and other places where the designer wants both good appearance and efficient light utilization.

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The PTL combines a rigid spun-aluminum reflector, an efficient Holophane® refractor, and a sturdy aluminum mounting base. Reflector swings open on hinge for easy cleaning, and for replacement of lamps and ballasts.

Reflector and base in natural brushed aluminum, or choice of pastel colors. Available with small cadmium-sulphide photo control, which automatically turns light on at dusk and off at dawn.

Choice of Five IES Patterns

For use with incandescent lamps up to 10,000 lumens, or 620 watts multiple; or with ballast in fixture for mercury vapor lamps up to 250 watts. Choice of five IES light patterns; types I, II, III, II 4-way, and V.

Two styles, for mounting on 3-inch or 7-inch poles. Tapered aluminum poles are available, to provide from 11- to 25-foot mounting heights.

Attractive Low Prices

Prices of the PTL luminaire start at $44; aluminum poles $46 and up. Mail the coupon below for free data sheets and details. Or contact any of the L-M offices listed on the other side.

THE NEW L-M PTL provides elegance of appearance and efficiently controlled light distribution. Available in brushed aluminum, or pastel colors, for 3- or 7-inch poles. For incandescent lamps, or with ballast for mercury vapor lamps. The PTL is also available with small photo control. Prices start at $44.

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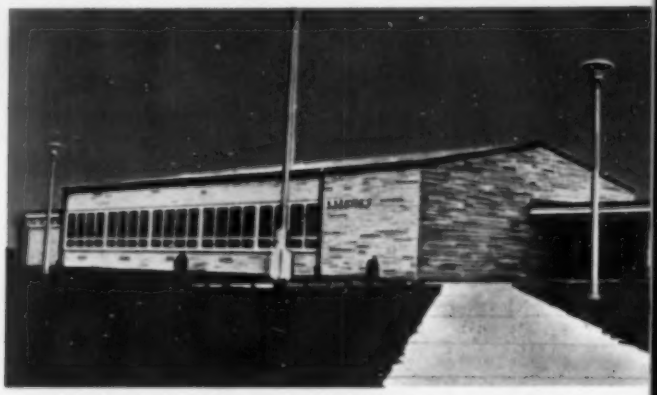
NEW L-M POST TOP LUMINAIRE

THE PTL is excellent for drive-ins, restaurants, hotels, motels, store fronts, shopping centers, water-front areas, railway stations, and many other applications.

Either incandescent or mercury lamps may be used. When the PTL is used for mercury vapor, the ballast is mounted in the fixture where it is easily accessible.

FOR INSTITUTIONAL OR RESIDENTIAL ground lighting, the PTL offers fine appearance, with efficiency. It spreads a soft, uniform light over a large area, with minimum glare.



NEW SCHOOL—NEW LIGHTING! L-M Post Top Luminaires add beauty to the facade, and provide excellent decorative and safety lighting for the area around the building.

. . . AND NOW. Conversion of this old light standard with a new PTL is more in keeping with the modern appearance of the building of the Bank of Naperville, Ill. The PTL will modernize most existing upright standards by direct replacement at a cost comparable to the replacement of two old-fashioned ornamental glass globe and canopy combinations.

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made of a PYREX® glass by Corning for General Electric

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Yes — if it's made from PYREX brand glass No. 7740 like this General Electric No. 500, made by Corning for use in the "R" IES Type incandescent assembly with lamps up to 620 watts.

With a PYREX brand glass you don't worry about danger from thermal breakage because you have high strength and low expansion. Because a PYREX refractor is rugged, you have fewer worries about breakage from vandalism, too.

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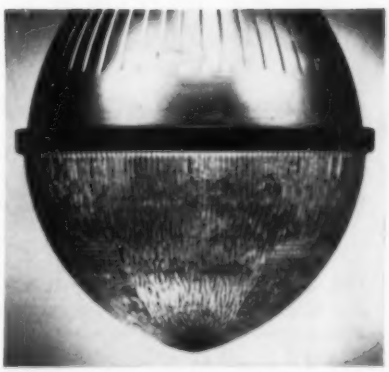
Let us help you solve your most pressing lighting problem. Spell it out in brief and send your note to Corning Glass Works, 61 Crystal Street, Corning, N. Y. You'll get a prompt answer.



PYREX refractor permits use of higher wattage lamps in this General Electric incandescent luminaire.

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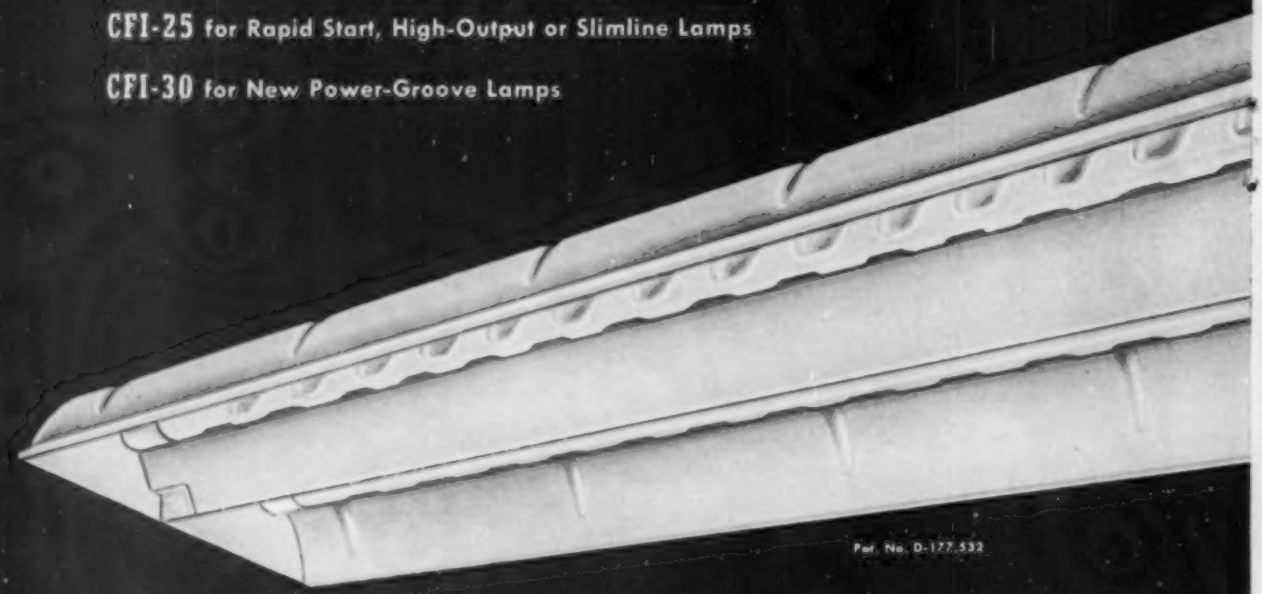
CORNING MEANS RESEARCH IN GLASS

Now your industrial lighting dollar buys up to twice the light with...

DAY-BRITE'S NEW CFI®

CFI-25 for Rapid Start, High-Output or Slimline Lamps

CFI-30 for New Power-Groove Lamps



Day-Brite announces "OPERATION UPLIGHT"

IN 1952—Day-Brite introduced Comfort For Industry with CFI lighting fixtures having slotted reflectors.

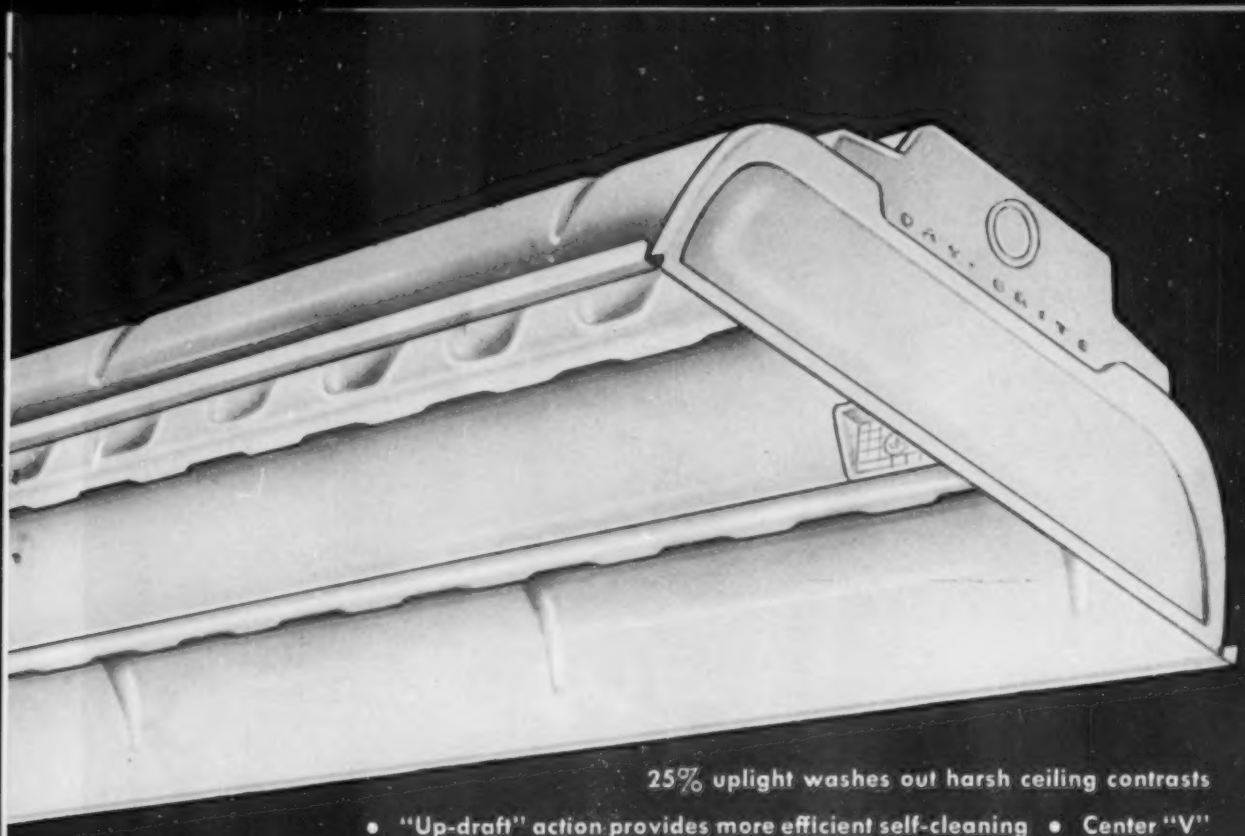
IN 1955—Day-Brite lowered installed costs for quality industrial lighting with improved CFI equipment.

TODAY—tests prove that industrial fixtures having 25% upward components and greater shielding provide *more light*... with *greater eye comfort*... at *lowest installed and total owning cost*... for *all* industrial lighting applications. OPERATION UPLIGHT is the result of these findings.

With OPERATION UPLIGHT, Day-Brite has now standardized its production of industrial fixtures on a basic, high uplighting design. Production savings are being passed along to buyers in PRICE REDUCTIONS AMOUNTING UP TO 17.7%.

Now one basic fixture, available in two adaptations for different lamps, delivers comfort lighting at lowest cost for *any* industrial application. Today's lower-priced Day-Brite CFI-30 fixture, used with new Power-Groove lamps having an output of 15,000 lumens, actually reduces the cost of lighting many industrial areas as much as 54%.

DAY-BRITE OPERATION UPLIGHT



25% uplight washes out harsh ceiling contrasts • "Up-draft" action provides more efficient self-cleaning • Center "V" and closed ends for added shielding and strength • Reflection surfaces are lifetime porcelain enamel for easy cleaning • 8-foot rigid channel, one-piece reflector for simplified installation • Spring-loaded sockets hold lamps securely, speed relamping • ALL THIS AT UP TO 17.7% LOWER COST!

UPLIGHT for higher lighting levels at lower cost

New lighting standards adopted by the Illuminating Engineering Society approximately *double* footcandle levels previously recommended. It is estimated that between 90 and 95% of existing lighting installations are now outdated.* And now, OPERATION UPLIGHT gives owners of industrial lighting systems these new reasons for relighting—without delay:

UPLIGHT for lower installed cost.

Day-Brite CFI-30 fixtures with new Power-Groove lamps reduce installed cost per square foot by *as much as 54%* because fixture prices are lower . . . and fewer fixtures are needed. And installation costs are also reduced because CFI equipment is designed to go up faster . . . with fewer parts to handle . . . and line up more easily.

UPLIGHT for lower operating cost.

The Taylor-Bradley research establishes *new maintenance factors* for industrial lighting . . . proves that Day-Brite CFI-25 fixtures lose *44% less* light output due to dust and dirt during 30 months' operation than units having solid top reflectors.

UPLIGHT for lower annual owning cost.

Day-Brite CFI-30 fixtures with new Power-Groove lamps reduce total annual owning cost by *up to 30%* compared with other fluorescent or mercury vapor systems . . . and *by 91%* compared with incandescent lighting.

PLUS . . . A BIG BONUS IN COMFORT.

Day-Brite's new CFI fixture not only delivers more light on the work plane, but also reduces eye strain and fatigue. Upward lighting *balances brightness.* Center "V" louver and fully enclosed ends (previously an extra cost feature on the CFI-25) help cut glare.

*ELECTRICAL CONSTRUCTION AND MAINTENANCE, NOV., 1958

This booklet tells how plant owners can save money through OPERATION UPLIGHT. For your copy, call your Day-Brite representative listed in the Yellow Pages. Or mail this coupon today.

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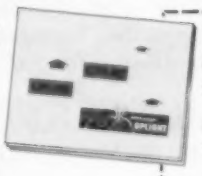

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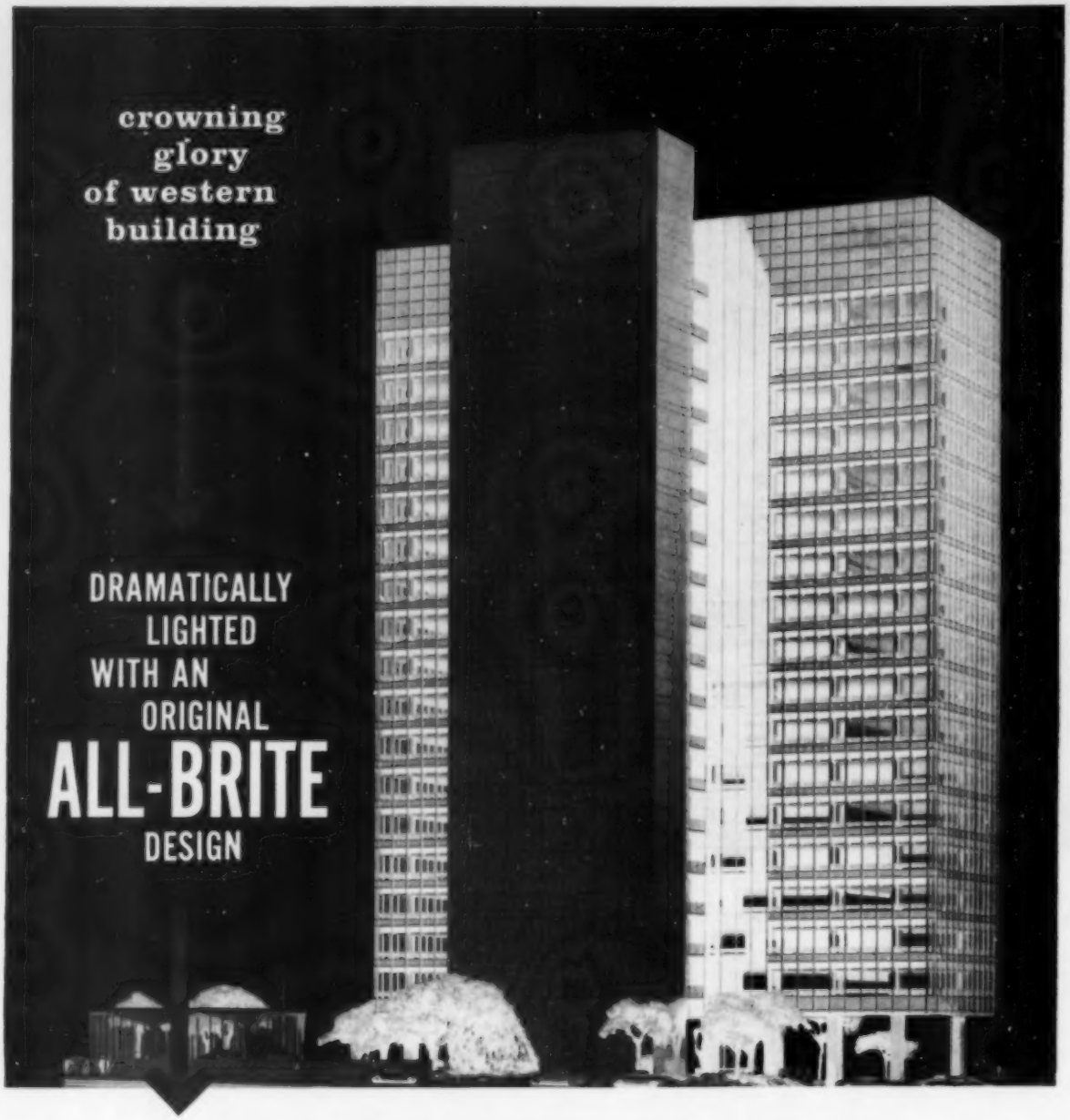

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The new concept, unitizing light, heat and ventilation in one superb recessed fixture. Result: greatly simplified installation and convenient maintenance. Detailed information on request.

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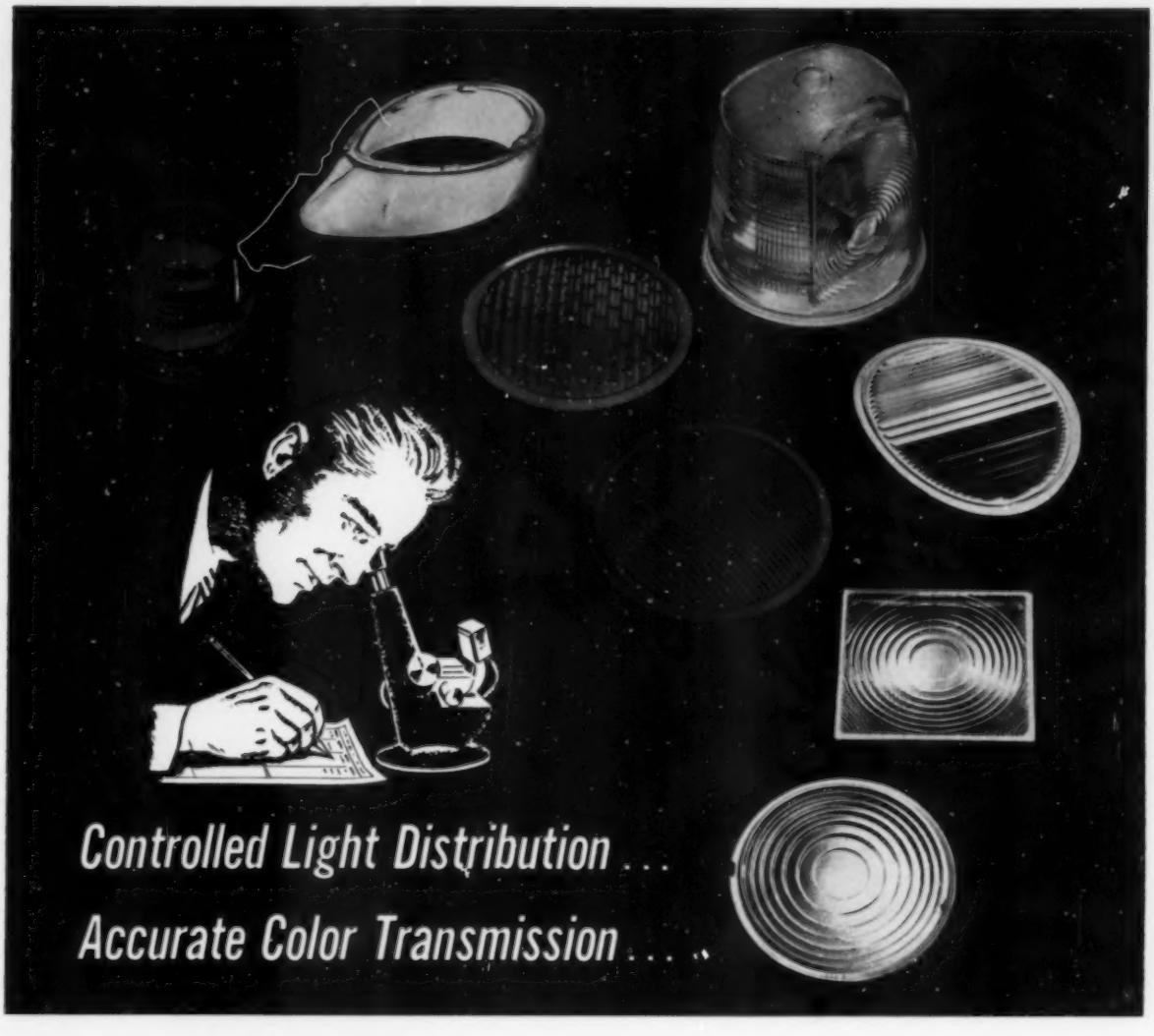

with *Kopp Engineered* Lighting Glassware

LENSES . . . COLOR FILTERS . . . COVER GLASSES

There's one important point of similarity in the various examples of lighting glassware seen here. Size, shape and glass composition are different in each case; but they are all engineered by Kopp technicians *to do a specific job.*

Some applications call for high strength and other physical characteristics, as well as light distribution and color transmission. In others, controlled light—whether concentrated, directed or diffused—may be as significant as dimensional stability, or heat-resistance. In fact, mechanical and transmission properties vary with each product, depending upon its end use.

Problem is—to engineer these items with the right combination of properties to meet individual application requirements. And Kopp engineers are specialists at doing just that. Write us, at Swissvale, Pennsylvania, about your needs. *Ask for bulletin 553-A on Kopp-Engineered Glass.*

Beneficial Properties

IMPACT RESISTANCE
BEAM CONTROL
HIGH TEMPERATURE CHARACTERISTICS
DIMENSIONAL STABILITY
ACCURATE COLOR VALUES
HIGH PHYSICAL STRENGTH
THERMAL-SHOCK RESISTANCE
CHEMICAL DURABILITY
ELECTRICAL ADVANTAGES

SPECIALISTS IN CUSTOM-BUILT LIGHTING GLASSWARE

Kopp Glass, INC.

KOPP GLASS

QUIET FLUORESCENT INSTALLATIONS

need proper planning...
and ***Jefferson*** *ballasts*

In many installations—particularly in hospitals, libraries, schools, churches, private offices and homes—noise is a critical factor. Ballast hum increases in proportion to the number of fixtures in a room. So, the greater the number of fixtures, the more urgent the need for ballasts with the best acoustical rating available.

The proper correlation of installation, fixture, room acoustics, and Jefferson SOUND CONTROLLED ballasts will result in a quiet installation. Use the sound control chart in the booklet offered here to select the proper Jefferson Ballasts for each room's characteristics. Then you'll have satisfactory installations—and satisfied, happy customers.

WRITE *for BULLETIN B-1000... data, prices, sound control chart*

Jefferson
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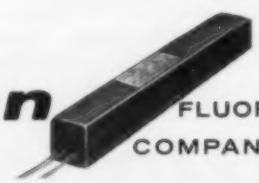

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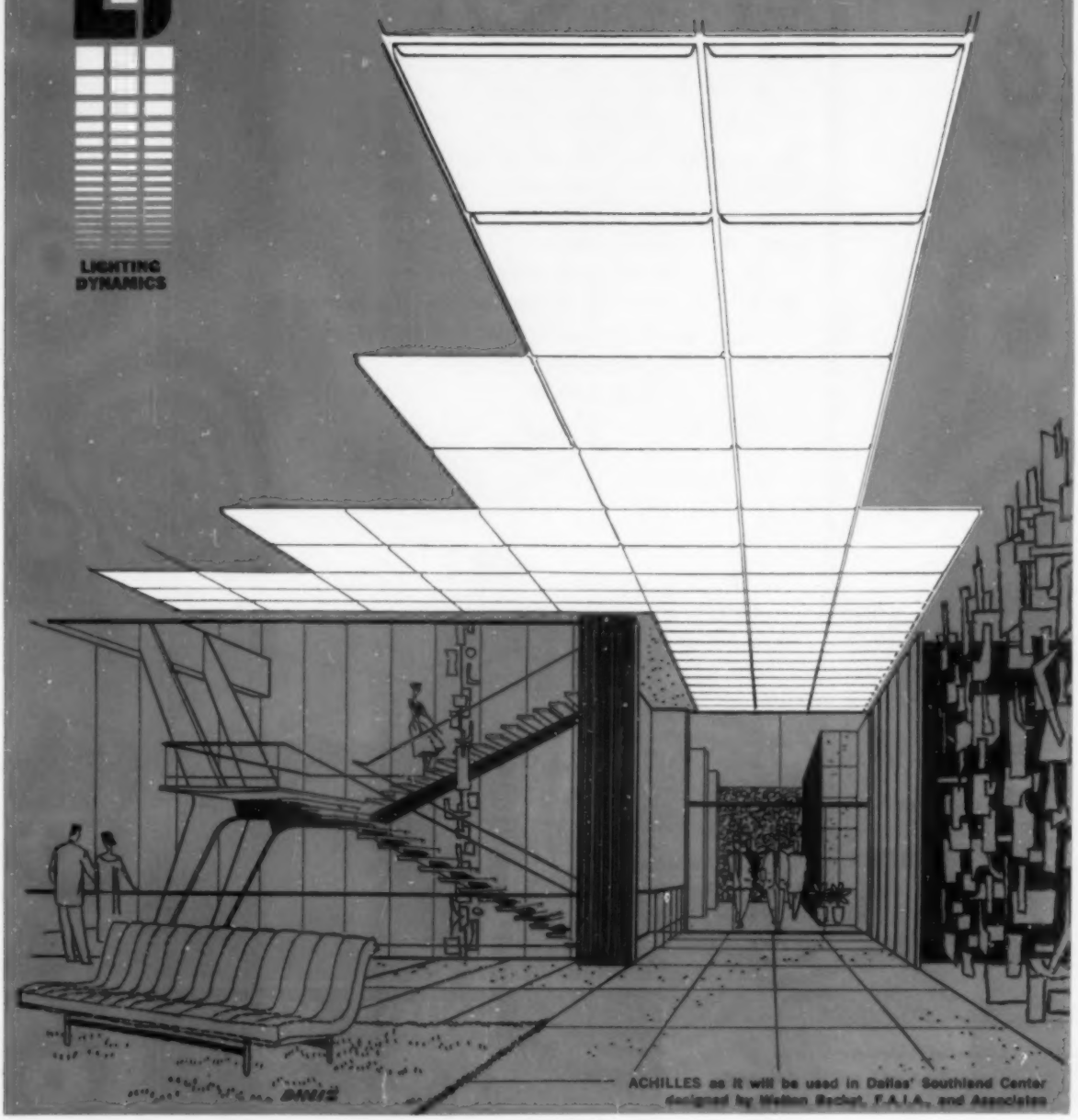
COMPANY • BELLWOOD, ILLINOIS

problem solution

An easily maintained, integrated fixture was needed for Welton Becket's dramatic "squares of light" ceiling in the lobbies and offices of Southland Life's spectacular 42-story Southland Center in Dallas.

ACHILLES by Lighting Dynamics was specified for the lobby... and it's companion Apollo was used in the offices throughout the center. Achilles is a highly versatile fixture series ideal for this demountable acoustical ceiling—just as it is for countless other ceiling suspension systems. It's quickly installed with a drop-in installation and has easy maintenance with press-to-open catches and hook-on hinges. Durable, Bonderized and electro-static, high-reflectance finishes... FOR MORE COMPLETE INFORMATION, call your Lighting Dynamics representative, or write to Lighting Dynamics, 802 West Whittier Blvd., Whittier, California or Lighting Dynamics, 8700 Ambassador Row, Dallas, Texas.

LIGHTING DYNAMICS



ACHILLES as it will be used in Dallas' Southland Center designed by Welton Becket, F.A.I.A., and Associates

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SAN JOSE STANDARDIZED

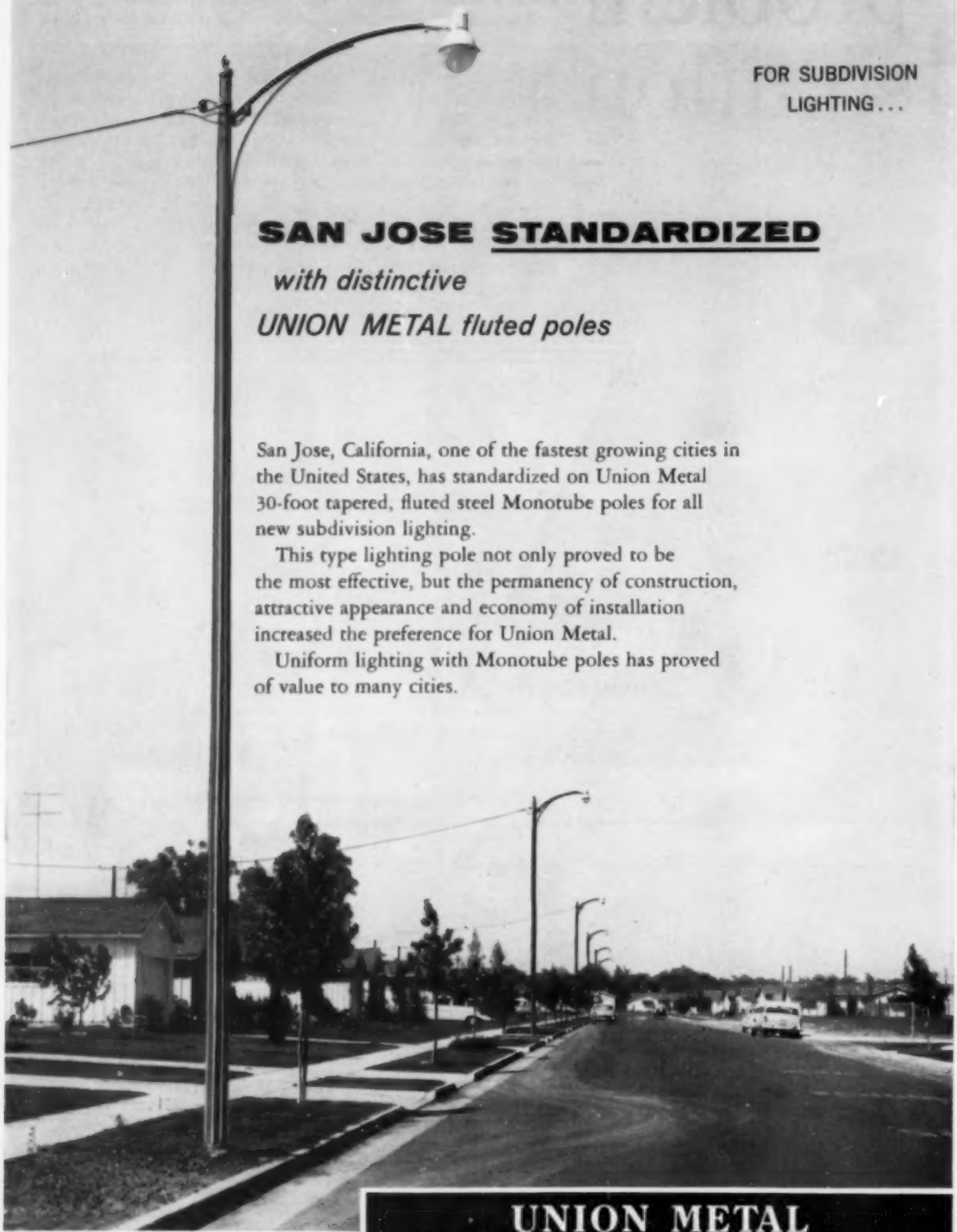
with distinctive

UNION METAL fluted poles

San Jose, California, one of the fastest growing cities in the United States, has standardized on Union Metal 30-foot tapered, fluted steel Monotube poles for all new subdivision lighting.

This type lighting pole not only proved to be the most effective, but the permanency of construction, attractive appearance and economy of installation increased the preference for Union Metal.

Uniform lighting with Monotube poles has proved of value to many cities.



Residential subdivision lighting... standardized with 30' Monotube poles mounting incandescent luminaires.

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The Union Metal Manufacturing Company

Canton 5, Ohio Brampton, Ontario, Canada

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on the market!"

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. . . a large area luminaire with POWER-GROOVE Lamps!
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A "FLOATING" CEILING.
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The "big idea" in lighting — to fit your own big ideas for the new and different in modern architectural settings! Simplified planning . . . with 5 sizes of *preassembled* modular units from 4′ x 4′ to 8′ x 6′. Modules are installed individually or joined in both directions, to provide the effect and the utility of dropped ceiling construction at low cost. High level illumination, architectural in form . . . functional and unobtrusive. Shielded by Holophane Controlens® #6024, Cubex aluminum ½″x½″x½″ louvers, Plastic louvers, or Polystyrene Plastic dishes. Fast, simple maintenance and re-lamping.

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America's finest fluorescent lighting

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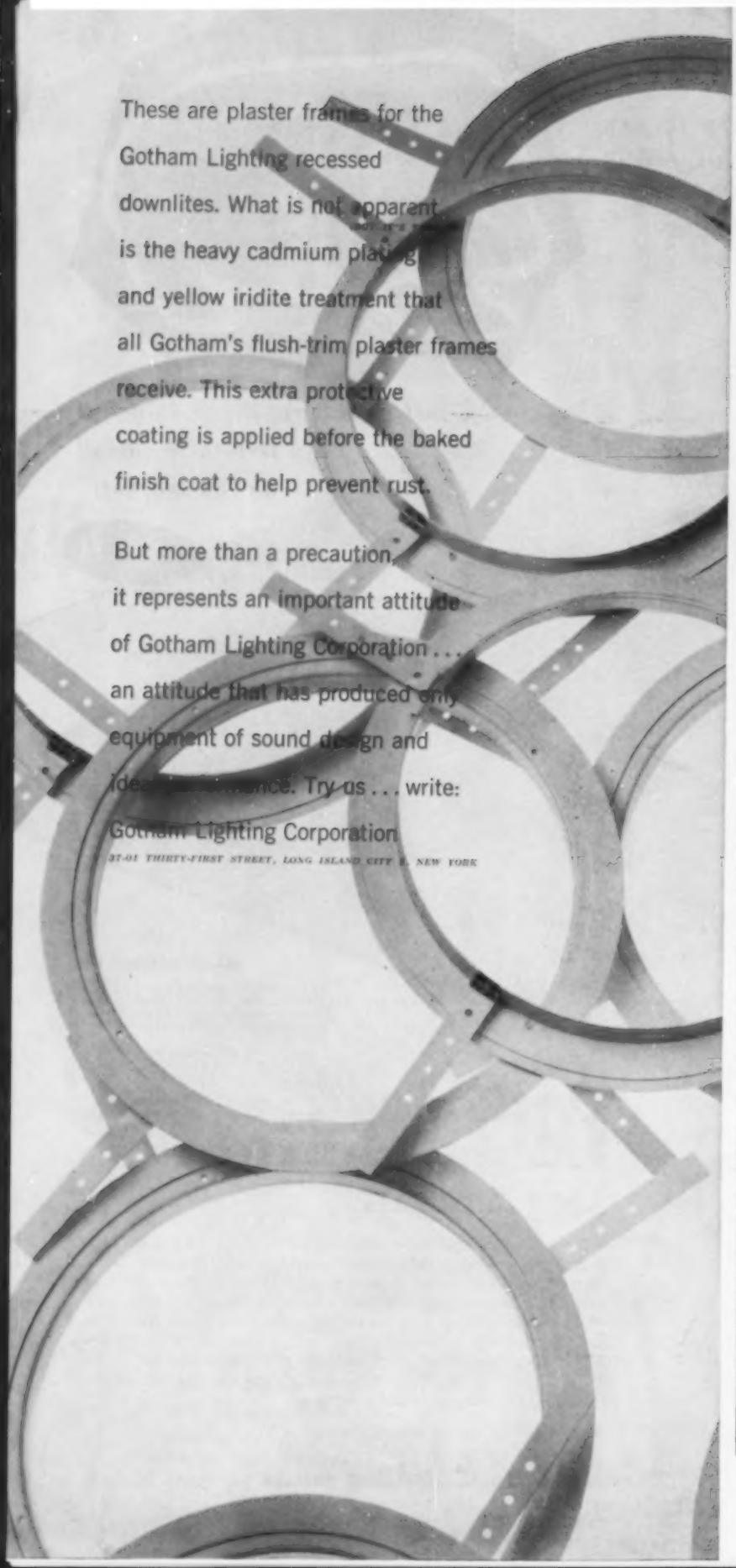
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coating is applied before the baked
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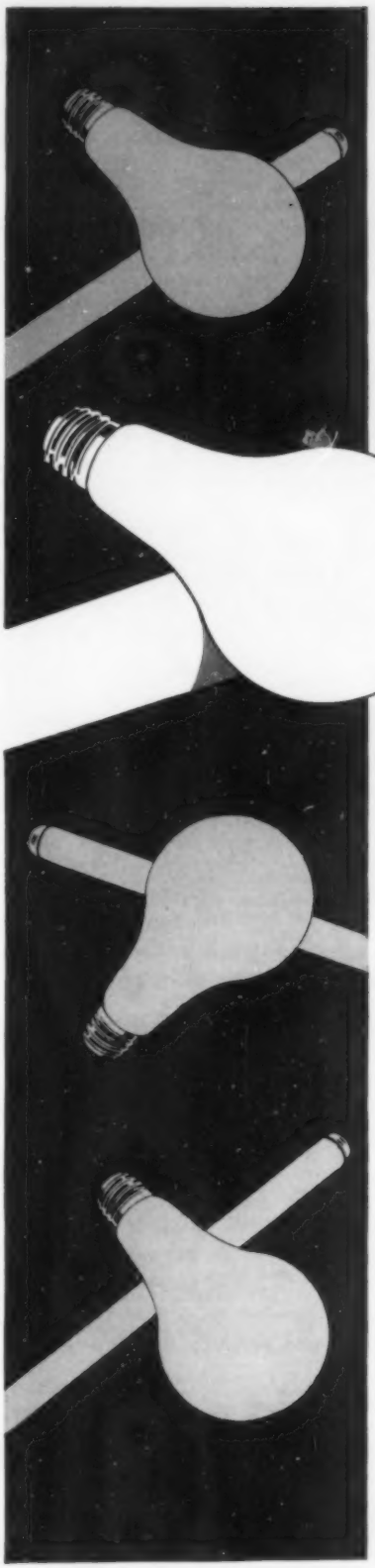

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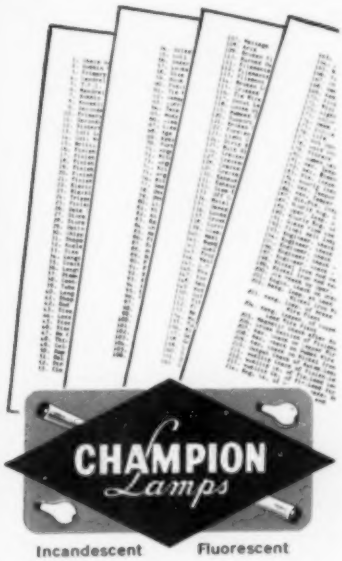

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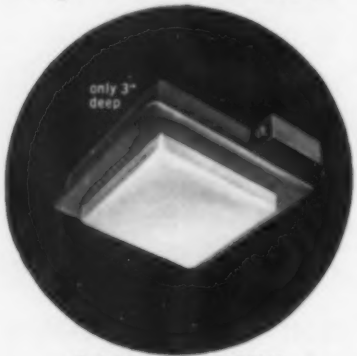

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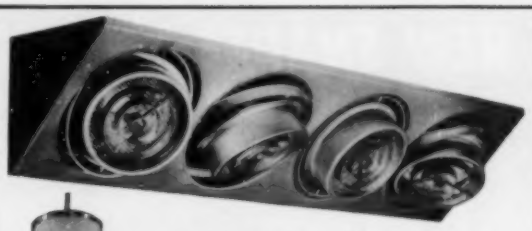

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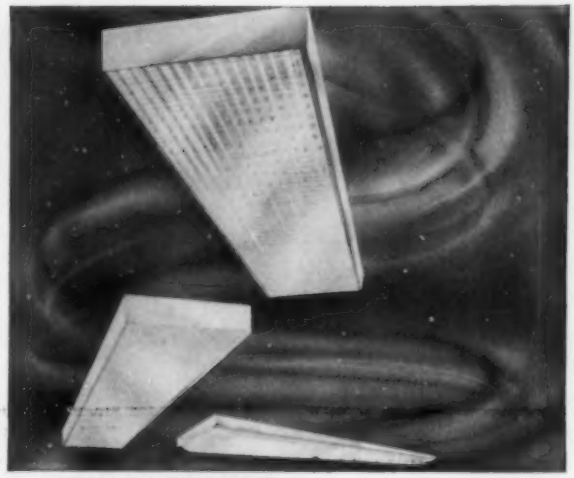

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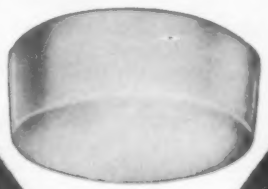

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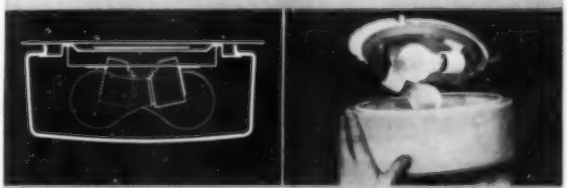

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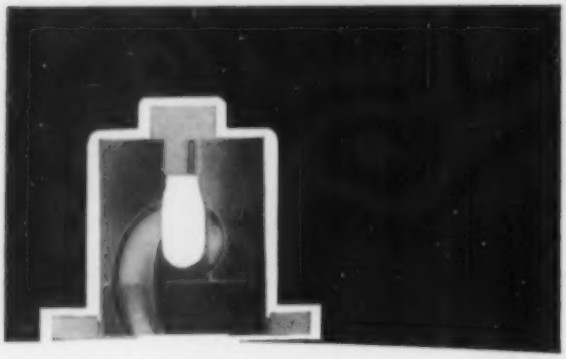

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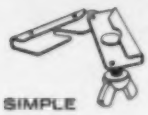

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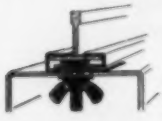

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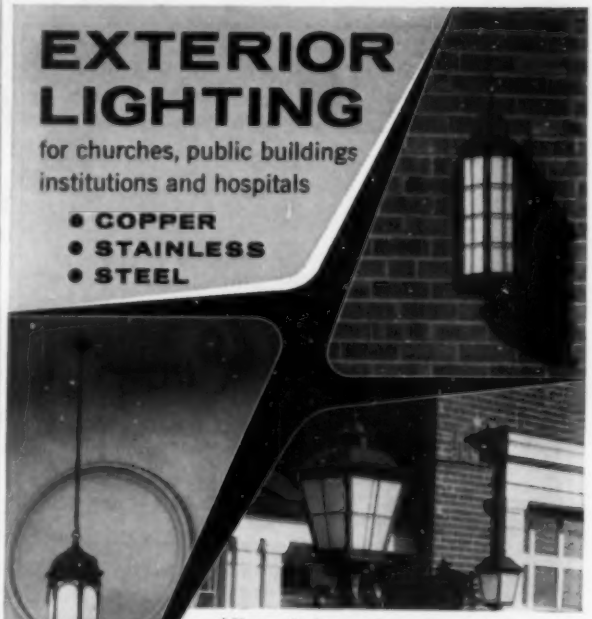

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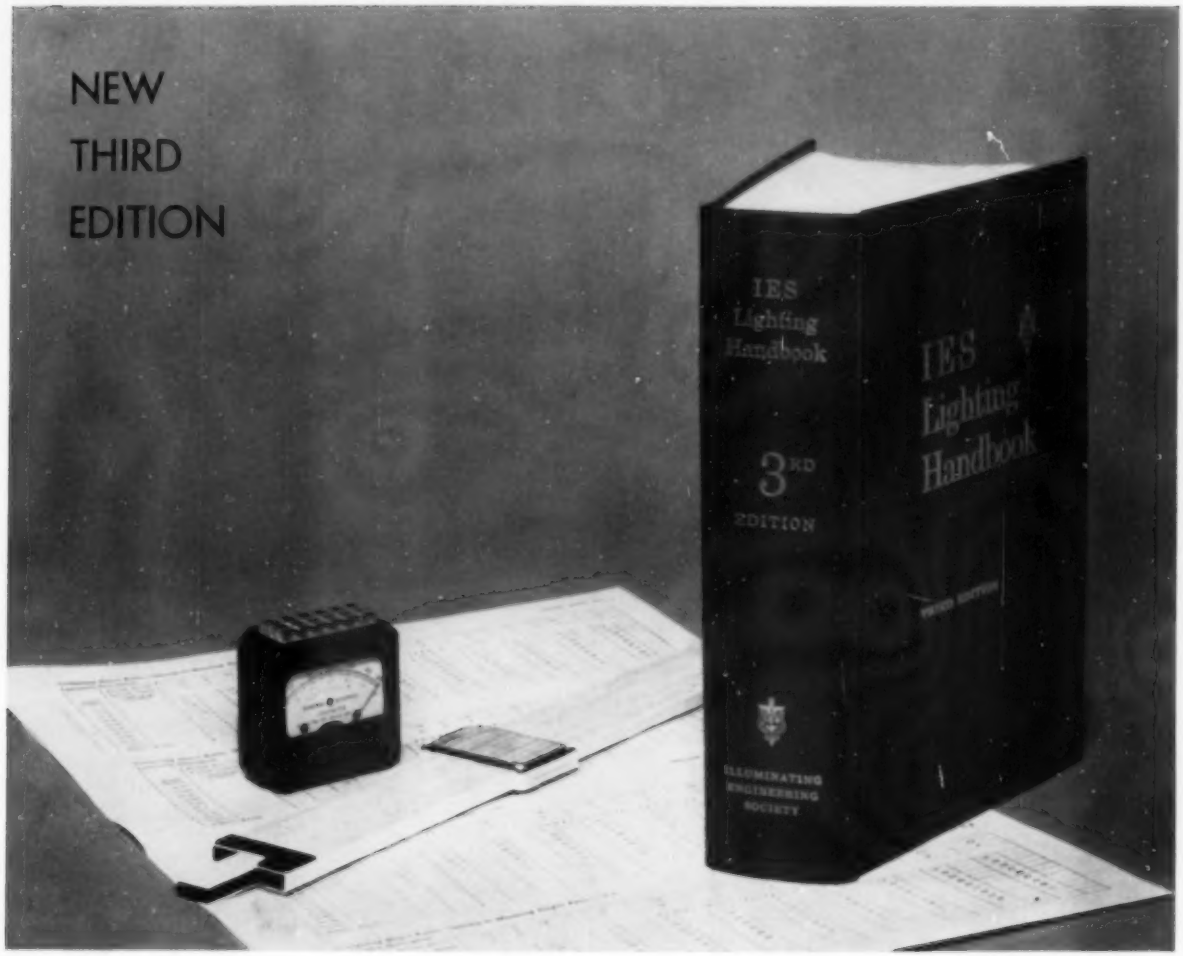

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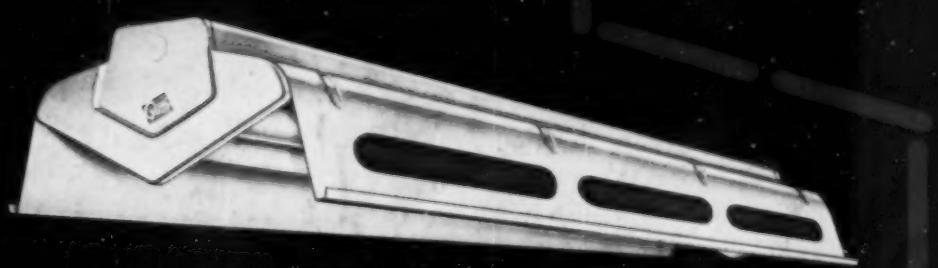

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